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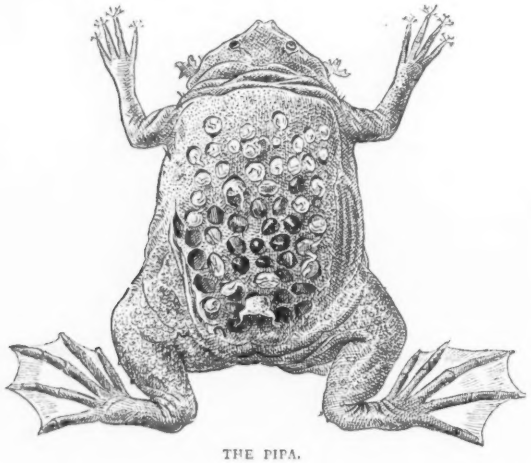
SOME STRANGE NURSING HABITS.

By R. LYDEKKER, B.A.Cantab., F.R.S.

WHILE the instinct of taking care of their progeny, whether these are born in the living state or first come into the world in the form of eggs, is more or less deeply implanted in the higher vertebrates, among the lower members of that great group the eggs and young are very frequently left to shift for themselves. Still this state of things is by no means universally the case; and we shall show in the course of the present article that certain amphibians and fishes exhibit structural modifications, for the purpose of protecting their eggs and young, which are almost or quite unparalleled elsewhere. Celebrated as they mostly are on account of their highly developed parental instincts, birds exhibit no instances where the body of either parent is specially modified for the purpose of carrying about either the young or the eggs after their extrusion. And we believe that the same holds good with regard to reptiles, although into the disputed question whether vipers afford protection to their young by allowing them to run down their throats we are not going to enter here, beyond confessing that we are inclined to trust the numerous observers who state that they have seen the phenomenon with their own eyes. With a certain group of mammals—the marsupials—the case is, however, very different, many of them, like the kangaroos, carrying their imperfectly developed young in a special pouch borne on the body of the female until sufficiently advanced to take care of themselves. In the females of certain other members of the same order, namely, some of the American opossums, the young are carried on the parental back, with their own tails tightly twisted round that of their mother; while bats carry their helpless offspring tightly clinging to their breasts, and the females of many lemurs bear them clinging transversely across the under surface of the lower part of their bodies. Now we shall find that among amphibians there are several instances where the eggs or young are carried about, either attached to the skin or borne in special receptacles; and as he knows that the relationship between mammals and amphibians is much closer than any which exists between the former and either birds or reptiles, the thoughtful naturalist cannot help being struck with this similarity as regards their nursing arrangements. Although not for one moment do we suggest that there has been any sort of inheritance in this matter, yet the coincidence is none the less striking.

Commencing with that group of amphibians represented by the frogs and toads, we find among these numerous instances of abnormal ways of protecting their young during the early stages of development, one of which has been known for nearly a couple of centuries, while many of the others have but recently been described. So far back as the year 1705, Fräulein Sibylla von Merian, in a work on the reptiles of Surinam, described a remarkable toad-like creature, in which the young are carried in a series of cells in the thick skin of the back of the female, which at this period has a honeycomb-like appearance. Till last year, when living examples were received by the London Zoological Society, the Surinam toad (*Pipa americana*), as the animal in question is called, was, we believe, only known in Europe by means of specimens preserved in spirit; and we have, therefore, been obliged to depend upon foreign observers for an account of its marvellous life-history. As it differs from other members of its order with regard to its method of bringing up its family, so the Surinam toad is structurally more or less unlike all its kindred, constituting not only a genus but likewise a family group by itself. Externally it is characterized by its short and triangular head, which is furnished with a large flap of skin at each corner of the mouth, and has very minute eyes. The four front toes are quite free, and terminate in expanded star-like tips; but a large web unites the whole five toes of the hind foot. In any state the creature is by no means a beauty, but when the female is carrying her nursery about with her she is absolutely repulsive in appearance. It would seem that soon after the eggs are laid, they are taken up by the male and pressed, one by one, into the cells in the thickened skin of his partner's back; there they grow till they fit closely to the hexagonal form of their prisons, each of which is closed above by a kind of trapdoor. After a period of some eighty-two days, the eggs reach their full development and produce, not tadpoles, but actually perfect little toads. The reason of this is that tadpoles, which require to breathe the air dissolved in water by means of their external gills, could not exist in the cells, and, consequently, this stage of the development is passed through very rapidly within the egg. When ready to come forth, the young toads, which are usually from sixty to seventy in number, although there may sometimes be over a

hundred, burst open the lids of their cells, and, after stretching forth their head or a limb, make their *début* in the world. Doubtless, glad to be free from her charge, the mother-toad thereupon rubs off what remains of the cells against any convenient stone or plant-stem, and



THE PIPA.

comes out in all the glory of a brand-new skin. During the non-breeding season these toads become much flattened, and seem to pass the whole of their time in water.

The Surinam toad is, however, by no means the only South American representative of its order whose nursery arrangements are peculiar, a considerable number of frogs and toads from the warmer regions of the New World having ideas of their own as to the proper method of bringing up a young family. Among these are certain species nearly allied to the familiar tree-frogs of Europe, but differing in that the females have a large pouch for the reception of the eggs. Unlike the kangaroos and other mammalian marsupials, in which the female has her nursing pouch on the under side of the body, these marsupial frogs (*Nototrema*) have this receptacle placed on the back, at the hinder end of which it forms a half-open tunnel, with its aperture directed backwards, although the pouch extends beneath the skin of the whole of the upper surface of the body. In this capacious nursery are deposited some fifteen or sixteen large eggs, which in due course develop into complete little frogs, without living tadpoles being produced, although at a certain stage the large eyes and long tail of a veritable tadpole are visible through the clear covering of the egg.

According to a communication recently made by Dr. Goeldi, of Rio de Janeiro, to the Zoological Society, the tree-frogs of the genus *Hyla*, inhabiting that part of Brazil, show considerable diversity in regard to nursing habits, although none of them have any part of their own body modified into a nursery. One species, for instance, builds nests of mud on the shallow borders of pools, wherein the eggs and tadpoles are protected from enemies, while another kind lays its eggs in a slimy mass attached to withered banana-leaves, the young remaining in this nest until they have passed through the tadpole-stage. In a third species, on the other hand, the larval stages are hurried through before hatching, the female carrying a load of eggs on her back, where they remain until developed into perfect frogs. Not long since, a female of this species thus loaded was exhibited alive at a meeting of the Zoological Society.

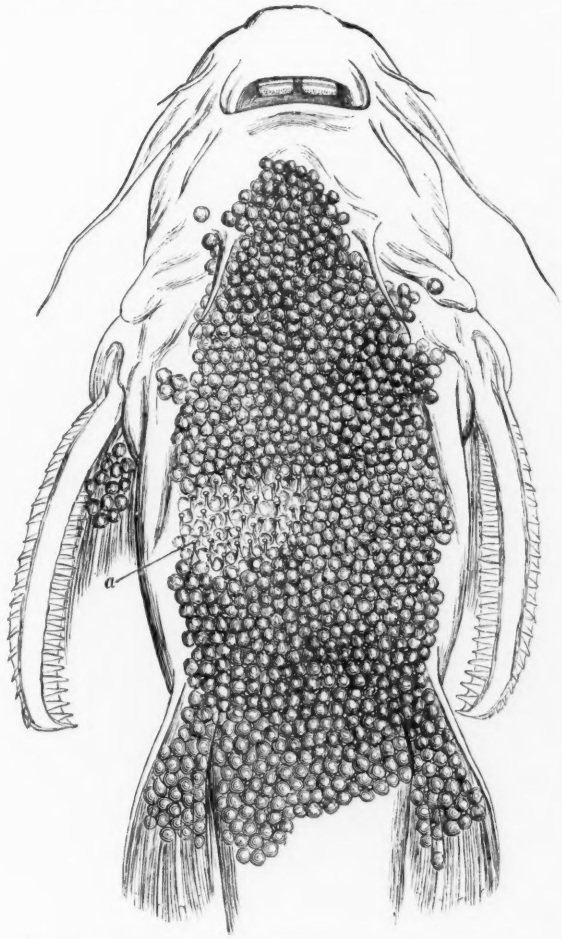
It will be observed that in all the foregoing instances the female parent takes charge of the eggs, either on or in her own body, or in a specially prepared nest, as soon as they are laid; but there are two genera of South American frogs in which it appears that, while the eggs are left to themselves, the tadpoles are carried about by their mother. The members of the one genus (*Dendrobates*) are tree-frogs from Surinam and Brazil, while the other species is from Venezuela, and belongs to the genus *Phyllobates*. Here the tadpoles, which may be from a dozen to eighteen in number, affix themselves to the body of their mother by their sucking mouths, and are thus carried about. In the case of one species of the genus first named, it appears that this mode of locomotion is only resorted to when the water is drying up and the mother desires to convey her offspring to other pools; but in the other forms the attachment seems to be more enduring.

The female of Darwin's frog (*Rhinoderma darwini*), from Chili, has, however, "gone one better" than all her allies, for not only does she get her eggs and young safely carried about until they are fit to take care of themselves, but she has actually shifted the onerous task of taking care of them to her consort. Whereas there is nothing remarkable about the structure of the female of this frog, the male has a capacious pouch underlying the whole of the lower surface of the body, which communicates with the exterior by means of a pair of apertures opening into the mouth on each side of the tongue. As soon as his partner has deposited her eggs, the male frog takes them in his front paws and transfers them to his mouth, whence they pass into the great nursing pouch, where they remain in perfect security till hatched into young frogs, which make their way into the world by the same passages.

Peculiar as is this method of taking care of the eggs, it is by no means altogether without a parallel in the animal kingdom, although we have to go to the class of fishes to find anything approaching a similar example. Among the so-called cat-fishes (*Siluridæ*), the males of several species of the large tropical genus *Arius* take the eggs into their mouth, whence they are transferred to the capacious pharynx, where they remain until hatched. It is also said that among the freshwater fishes of the chromid family, the males of the typical genus inhabiting the Sea of Galilee take charge of the eggs in a similar manner. Indeed, among the comparatively few fishes that take any care at all of their ova, the charge almost invariably falls to the share of the long-suffering male, whose partner, having laid the eggs, appears to think that she has done quite enough in family matters, and is at full liberty to enjoy herself as she pleases.

Of the two definitely known instances in which female fish take care of their eggs, one occurs among the aforesaid family of the cat-fishes, in the genus *Aspredo*, represented by some half-dozen species from the Guianas. In these fish, none of which exceed a foot and a half in length, the large eggs are carried on the under-surface of the body of the female, where they form a shield-like mass extending from a short distance behind the mouth on to the pelvic fins. In some respects the position of the ova recalls a female freshwater crayfish in the breeding-season; but a closer resemblance exists between the fish in question and the Surinam toad already described, although in one case the female bears her load upon her back, and in the other under her abdomen. In both instances the eggs are, however, pressed into the soft spongy skin, the female cat-fish effecting this operation by lying closely upon the newly deposited spawn. Instead of being completely

buried in closed cells, the eggs of the fish remain partly exposed, and are thus carried about till they are hatched; the rugosities then disappear from the skin of the abdomen of the parent, which resumes its normal smoothness.



Abdomen of *Aspredo batrachus*, with the ova attached; at *a*, the ova are removed, to show the spongy structure of the skin, and the processes filling the interspaces between the ova. Natural size.
From Günther's "Study of Fishes."

Everybody who has been in the habit of partaking of whitebait will probably have occasionally observed among the contents of his plate a long, slender, bony fish, with a pipe-like nose, which has evidently no claim to kindred with its neighbours. This fish is a young representative of the pipe-fishes, which, together with the so-called sea-horses, so well known for their habit of curling their tails round the stems of seaweed, constitute a family especially remarkable for the variety and curious nature of their nursery arrangements. Among these an Oriental genus of small pipe-fishes (*Solenostoma*) agrees with the fish last mentioned in that the female takes charge of the eggs. For this purpose she is provided on the lower surface of her body with a roomy pouch, formed by the coalescence of the pelvic fins with the skin of the abdomen. The inner walls of this pouch are furnished with long filaments, which aid in keeping the egg in position; and it is highly probable that after the young fish are hatched they are retained for some time by attachment to the walls of the chamber. In the true pipe-fishes (*Syngnathus*), on the other hand, the task of looking after the nursery falls to the males, which are provided with a long pouch on the under surface of the tail, formed by a fold of skin arising on each side, and the two meeting in the middle line. How the eggs are conveyed into this pouch we are totally unaware, but when once there, they are completely enclosed by the junction of the edges of the two folds of skin, and thus remain till they are hatched into minute eel-like pipe-fish, which soon make their way into the world by thrusting open the folds of the pouch. In the sea-horses, the development is carried one stage further, the nursing pouch being completely closed along the middle line, and only communicating with the exterior by means of a small aperture at the anterior end, through which the eggs are by some means or other introduced, and by which in due course the young make their escape. Certain pipe-fishes (*Doryichthys*) differ from the ordinary forms in that the males have the pouch situated beneath the abdomen instead of under the tail; and it is not a little remarkable that in certain allied genera (*Nerophis*, etc.) the eggs are simply attached to the lower surface of the abdomen of the male without the development of a pouch. We have thus an excellent instance of the evolution of a special organ, so far as the abdominal pouch is concerned; but it would seem highly probable that the caudal pouch of the allied forms must have been independently evolved, in which event we should have a remarkable example of parallelism in development.

Although many fishes retain their eggs within their bodies until the young are hatched and attain a considerable size, we are not aware that any others have special arrangements for carrying about their eggs after extrusion, with the exception of the aberrant lung-fish (*Protopterus*) of tropical Africa. In this genus the numerous eggs and embryos are reported to be nursed in a long gelatinous pouch attached to the sides of the back of one of the parents, although which of the two is charged with this office does not appear to be ascertained. Several kinds of fish are, however, in the habit of constructing nests for the reception of their eggs, while a few take advantage of other animals for their protection. For instance, the females of the small roach-like fishes, of which the Continental bitterling (*Rhodeus amarus*) is the only European example, have the oviduct periodically prolonged into a tube of considerable length, by means of which the eggs are introduced within the shells of living freshwater bivalve molluscs, where they remain secure from foes until hatched. Among the nest-building species the most familiar are the bullheads (*Cottus*), sticklebacks (*Gastrosteus*), and lump-suckers (*Cyclopterus*), in all of which, as in the other instances, the nest is formed and guarded by the male fish. In the sea-stickleback the nest is a large structure composed of pendant seaweeds, tightly bound together into

Sub-caudal pouch of *Syngnathus acus*, with the young ready to leave the pouch. One side of the membrane of the pouch is pushed aside to admit of a view of its interior. Natural size. From Günther's "Study of Fishes."

a pear-shaped mass by means of a silk-like thread. When the eggs are safely deposited within its interior, the male fish immediately mounts guard, and has been known to continue uninterruptedly at his post for upwards of three weeks. Should any damage happen to the nest, so that the precious eggs lie open to the attack of any predaceous wanderer, the janitor forthwith sets to work with the greatest energy to repair the damage, poking his nose into the structure, and rearranging the materials till all is made right. Nests are also made by the freshwater species, and guarded with the same care; the male frequently stirring up the eggs with his snout, and often keeping up a fan-like movement of his fins for the apparent purpose of ensuring a continual change of the water. Many other fishes construct more or less elaborately formed nests, but even when no nest is built, the males are in the habit of mounting guard over the eggs; this being the case with the bow-fin (*Amia calva*), so abundant in the lakes of North America.

Such are some of the chief instances among amphibians and fishes where special arrangements—either of structure or of habit—are made for the protection of the eggs and young; and although these bear but a small proportion to the cases where the latter are left to themselves, yet they are sufficient to show that in these respects these two animals present peculiarities unknown among other vertebrates. Why such special arrangements have been evolved in these cases, or whether the groups in which they occur have any advantage in the struggle for existence over their fellows, are questions which, for the present at least, must remain unanswered.

THE PLACE OF IRON IN NATURE.

By John T. Kemp, M.A.Cantab.

FEW elements are more abundant in nature than iron, whilst none is more widely distributed. Its compounds pervade every portion of the earth's crust. Among massive and stratified rocks alike, ferruginous deposits exist on an enormous scale, frequently assuming mountainous dimensions or covering many hundred square miles. The variety of their composition is hardly less remarkable. Thus the useful ores include ferric oxide (Fe_2O_3), known in the crystallized condition as specular iron ore, and in the amorphous state as hæmatite; the magnetic oxide (Fe_3O_4), or magnetite; ferric hydrate (Fe_2O_3 + water), which occurs sparingly in the crystalline form as the mineral gothite (Fe_2O_3,H_2O), but abounds in the amorphous condition of limonite ($2Fe_2O_3,3H_2O$, but probably a mixture of several hydrates); titaniferous iron, a mixture of ferric oxide with a variable proportion of titanic oxide (TiO_2); ferrous carbonate ($FeCO_3$), or spathic iron ore, with impure varities known as clay ironstone. To these must be added iron disulphide (FeS_2), of which two crystalline modifications occur, viz., iron pyrites, commonly met with in the form of brass-yellow cubes, and marcasite, much lighter in colour with a radiated structure. Among less abundant but noteworthy compounds may be mentioned magnetic pyrites (Fe_3S_4); copper pyrites (Cu_2S,Fe_2S_3), one of the most abundant ores of that metal; mispickel, or arsenical pyrites (FeSAs), the principal source of arsenic; vivianite, a ferrous phosphate of variable composition, met with in beds in which animal matter has decayed, often of a brilliant blue colour.

A few illustrations of the magnitude of some ferruginous deposits may here be quoted. Pilot Knob, in Missouri, a hill seven hundred feet high, consists almost entirely of a single mass of hæmatite. Near Gellivara, in the north of Sweden, a mountain of magnetite exists, whose dimensions are reported as sixteen thousand feet long, eight thousand feet broad, and two thousand feet high. Beds of magnetite are met with among the Archæan rocks of Canada up to two hundred feet in thickness. In the same region are immense deposits of hæmatite, titaniferous ore, and iron sulphides. Zirkel describes Erzberg, a mountain in Styria, rising two thousand feet above the neighbouring valley, as composed almost exclusively of spathic iron ore.

Besides those ferruginous deposits which from their form or dimensions are entitled to rank as independent rock masses, hosts of smaller aggregations are met with, such as veins, encrusting layers, nodules, and scattered crystals. Thus hæmatite often occurs in veins traversing crystalline rocks, whilst layers of ferric hydrate are deposited in their channels by waters containing iron, both above and below the surface. Many of the septarian masses so common in clayey strata consist essentially of clay ironstone. Hæmatite nodules, often containing fossil remains, abound among some of the carboniferous beds. Masses and single crystals of iron pyrites occur plentifully in some strata, marcasite in others, but what conditions determine the form assumed by the sulphide we do not know. The various "greensands" owe their appellation to the presence of grains of an iron silicate of very variable composition, known as glauconite; deposits of the same mineral are now forming in certain parts of the sea-bed. Magnetite may here be mentioned as an essential constituent of basalt and other volcanic rocks, in which it occurs in the form of opaque octahedral crystals.

The most striking evidence of the universal presence of iron in nature is, however, found in the colours imparted by its compounds. Iron has justly been called "the great pigment of nature." Few deposits there are which are not tinged with iron in one chemical form or another. To it are due the brown, yellow, red, green, blue and creamy tints which in endless variety characterize the vast majority of rocks. Green and blue colorations are produced generally by ferrous compounds, red by ferric anhydride, and yellow and brown tints by ferric hydrates. The presence of other substances, such as carbonaceous matter, largely affects the coloration in many instances.

Probably not more than eight or possibly ten of the elements occur in the earth's crust in larger proportion than iron. The significance of this fact will be appreciated when it is added that ninety-nine out of a hundred parts by weight of the crust are estimated to be composed of some sixteen elements at the most, leaving fifty or more which constitute the remaining one-hundreth part. Nevertheless, in comparison with oxygen, silicon and aluminium, of which about eighty-five per cent. of the accessible rocks consist, a decidedly low place must be assigned to iron as constituting probably less than one per cent. of the whole, so rapidly does the relative abundance of the elements fall off. About half of the earth's crust is composed of oxygen.

Iron is, as would naturally be expected from the universality of its occurrence elsewhere, one of the elements, some thirty in all, which have been detected in the oceanic waters. Messrs. Thorpe and Morton report the presence of ferrous carbonate to the extent of one part in two hundred thousand in the water of the Irish Sea collected during winter. This proportion, if maintained throughout the ocean, would indicate the existence of more than four billion tons of metallic iron in solution.

In the organic world, again, iron appears to play an indispensable part. It is an essential constituent of the

blood, whilst the production of chlorophyll in plants has been experimentally proved to be, in some way as yet imperfectly understood, dependent on the presence of iron in their nutriment. According to Ehrenberg some species of diatoms secrete ferric oxide in considerable quantities.

But the existence of iron is not confined to our own planet. The spectroscope reveals its presence in the sun and many of the stars. It is also the chief constituent of meteorites.

Native iron is of very rare occurrence among the terrestrial rocks. Veins are all but unknown. It has most frequently been detected in the form of grains scattered through certain eruptive rocks, such as the gabbros belonging to the volcanic outbursts of Mull and Skye during the Tertiary period, and in the basalt of the Giant's Causeway. Nordenskiold has discovered in the island of Disco, off the west coast of Greenland, a number of large masses of iron, one weighing nearly twelve tons; but whether they are of terrestrial origin is doubtful. Similar masses occur in the basalt of the vicinity. The great traveller himself regarded them as memorials of a meteoric fall during the outflowing of the rock in Tertiary times; but Daubrée has shown that the rock contains microscopic particles of iron, associated with certain other minerals in such a way as to exclude the hypothesis of the conjunction being accidental. He therefore concludes that the iron came from below with the other constituents of the mass.

This subject naturally raises the question, so often asked in view of the high density (about 5·5) of the earth as a whole compared with the average density (say 2·5) of the surface rocks, viz., whether the interior contains large quantities of iron or other uncombined metals. Taking as a guide Sir A. Geikie's list of the sixteen most abundant elements—to wit, O, Si, C, S, H, Cl, P, F, Al, Ca, Mg, K, Na, Fe, Mn, Ba—it is observable that their heaviest combinations with one another barely reach the minimum specific gravity required to account for the earth's density. Whether the enormous pressure, vastly greater than any whose effects we can observe in our laboratories, to which the earth's internal layers are subjected, would serve to compress the materials to the requisite degree is exceedingly doubtful, whilst it is certain that the high internal temperature of the earth's interior must, to a large extent, counteract the reduction of volume through pressure. It seems most probable, therefore, that extensive deposits of heavy materials of some kind exist in the interior of the earth, and of such none is more likely to abound than iron, considering its high rank as a constituent of the crust.

Meteoric iron is known in masses varying from many tons in weight down to microscopic grains. The latter have been detected in the snows of the Alps and the Arctic regions, and caught on board ship in mid-ocean by means of sheets of glass smeared with glycerine and exposed to the wind. Grains of metallic iron abound in the red clay of the Atlantic Ocean, a fact which may be taken as a proof of its slow growth. Meteoric iron is invariably alloyed with metallic nickel. Until recently the natural occurrence of "nickel-iron" (as the alloy is termed, notwithstanding the predominance of the latter element) was unknown except as a constituent of meteorites. Masses of an alloy of the two metals (with other materials) have, however, been lately discovered in the gravel of a stream in Oregon, which differ in some remarkable respects from all meteorites hitherto known. Thus they do not exhibit the peculiar markings, termed "Widmannstatt's figures," when treated with nitric or hydrochloric acid. Josephinite is the name which has been given to the new mineral.

Iron is also found alloyed with platinum. A specimen from Siberia analyzed by Berzelius was found to contain 86·50 per cent. of platinum, 8·32 per cent. of iron, together with small quantities of palladium, rhodium, copper and "gangue." Another sample from South America contained, of platinum 84·30 per cent., of iron 5·31 per cent., of rhodium 3·46 per cent., besides palladium, iridium, osmium and copper, seven metals in all.

BREATH-FIGURES.

By DR. J. G. MCPHERSON, F.R.S.E., *formerly Mathematical Examiner in the University of St. Andrews.*

THERE is something exceedingly fascinating about the curious set of phenomena known as breath-figures, and the explanation of their existence. New light has lately been thrown upon their nature; and their study is interesting.

Fifty years ago, Prof. Karsten, of Berlin, placed a coin on a piece of clean plain glass, and passed through it a current of electricity. Nothing was seen on the glass when the coin was removed, but when he breathed on the plate the characters of the coin became visible. At the same time Sir W. R. Grove succeeded in producing impressions with simple paper forms. Möser, of Königsberg, produced figures on polished surfaces by placing on them rough bodies. Riess described a breath-track made on glass by a feeble electrical discharge.

But Mr. W. B. Croft has lately been investigating the matter with exemplary care and perseverance; for it requires some practice to manage the electrification properly. This was his most successful plan: Place a glass plate on a table for insulation, and put a coin of any metal on the centre of the plate. In many cases the image on the coin does not touch the glass on account of the projecting ring; but these seem to be best suited for the experiment. Arrange a strip of tinfoil from the coin to the edge of the glass; on the coin place a smaller plate of glass, and above that plate place a second coin. Connect the tinfoil and the upper coin with the poles of an electric machine, and turn the handle of the machine for two minutes, so that continuous sparks may pass. On taking up the glass, nothing can be seen on it, even with the help of a magnifying glass. Yet on the glass there is a latent impression; for, by breathing on the side of the glass next the coin, a clear frosted picture of that side of the coin which had faced it will be produced, even to the smallest details. The whole projecting parts of the coin have a black counterpart, and there is a marvellously fine gradation of shade corresponding with the depth of cutting on the coin. If this breath-figure be examined under a microscope, the moisture will be seen really deposited over the whole; but the size of the minute water-particles increases as the part of the picture is darker in shade. Around the coin's disc is a black ring, a quarter of an inch in breadth. Should the coin used have milled edges, radial lines will pass through this ring.

If these breath-figures are carefully protected, there is no apparent limit to their permanence, even for years. Months after they have been set aside, the black ring round the disc gradually changes into several rings, forming beautiful concentric alternations of black and white. If half-a-dozen coins, lying in contact side by side in the form of a cross, be placed on insulated glass, then over the coins a test glass, with a corresponding cross of coins above it, beautiful breath-figures will be produced. In the black spaces between the circles are clear white lines which are common tangents to the circles, when the coins

are of the same size. If coins and glass plates be piled up alternately, and the outer coins be connected with the poles of the electric machine, perfect images are formed on both sides of each glass. If several glasses be placed between two coins, only two images will be produced, one on each of the outside glasses. In all cases the glasses must be scrupulously well cleaned with chamois leather.

Heat will produce similar results by the molecular bombardment to which the surface of the cold glass would be exposed by the gases heated by the coin. If a very hot, clean coin be placed on a cold mirror, and be removed after being cooled down, nothing will be seen on the glass. But if the mirror be breathed upon, an exact image of the coin becomes visible. If the point of a blowpipe be passed over a clean mirror, with sufficient quickness to prevent the sudden heating from breaking it, nothing is seen after the glass is cold. But if you breathe upon its surface, the track of the flame is clearly marked. While most of the surface looks white in consequence of the light reflected by the deposited moisture, the track of the flame is quite black. But under a microscope this track is discovered to be wet with a thin, even film. If the jet of the blowpipe be tracked over the mirror so as to form figures, the breath on the cold plate will reveal the figures, traced with great distinctness. The hot coin in some way seems to alter the dust-particles on the mirror, causing them at certain parts to reflect more light than at others, to be brought out more plainly when the moist breath develops them.

Probably all polished surfaces may be similarly affected. A plate of quartz gives most beautiful images, perfect in details, retaining their freshness longer than those on glass. If a piece of mica be split, and a coin be slightly pressed for half a minute on the new surface, without any current of electricity or application of heat at all, a breath-figure of the coin is left behind. If a leaf of paper, printed on one side and thoroughly dry, be placed between two plates of glass, and left for ten hours either in the daylight or in the darkness (a slight weight being placed over to keep the paper even), nothing is seen; but as soon as you breathe on the glass, a perfect breath-impression is made of the print on both pieces of glass. These are generally white, and are most easily produced during keen frost. If paper devices be placed for a few hours under a plate of glass, clear breath-figures of the devices will be produced when you breathe on the glass. After an ivory point has been traced in any shape over a glass plate with slight pressure, a black breath-figure of the writing is made at once. If plates of glass lie for some hours on a table-cover which has on it figures worked in silk, strong white breath-figures are impressed on the plates, the silk coming out white and the cotton black.

Some exceedingly curious permanent illustrations of the phenomena are to be found. There are several impressions of brasses in the basement under Henry IV.'s chantry in Canterbury Cathedral. On the walls appear shapes of the effigies. Sometimes the stone is unstained all over the area of the figure, but surrounded by a broad, dark smudge; and in other cases the reverse is found, the area of the figures being indicated by a uniform dark tint, whilst the surrounding stone is unstained. Friends of Mr. Croft, who can be trusted for their authentic evidence, give two remarkably interesting cases of breath-figures of this permanent description. The plate-glass window of a hotel in London has on the inside a screen of ground-glass lying near, but not touching; upon the latter are the words "Coffee Room" in clear, unfrosted letters. When the screen was taken away the words were left plainly visible on the window, and no washing would remove them. A house in London had been a hotel three years before; on one of the windows had been a brown gauze blind, with the gilt letters "Coffee Room" on it. On misty days the words "Coffee Room" are distinctly seen, but not on other days. This is a marvellously accurate instance of permanent breath-figures, the mist acting like the breath, depositing the moisture on the glass. There is no doubt that a little observation on the part of our readers would reveal many curiosities of this kind in old houses, or at railway stations.

No one, as yet, has clearly explained how these impressions are produced by electricity and heat. The fact always confronts us that the simpler the phenomena the more difficult is the explanation.

ON THE TWO FORMS OF PRIMROSE.

By the Rev. Alex. S. Wilson, M.A., B.Sc.

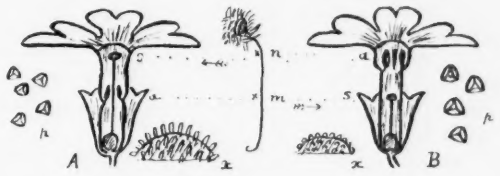
If a number of common primroses be examined, they will be found to consist of about equal proportions of two kinds of flower, differing somewhat from each other. In one set, the "pin-eyed" as they are called, the centre of the flower is occupied by a round knob resembling the head of a good-sized pin; this is the stigma or extremity of the seed-vessel, to which the pollen is applied in fertilization. Externally, the anthers of the pin-eyed primrose are not visible, since they stand midway down the inside of the flower-tube. A flower of the other or "thrum-eyed" form has the relative positions of these organs reversed; at the mouth of the flower are the five anthers, while the stigma, which is situated halfway down the tube, cannot be seen without cutting open the corolla. Vertical sections of the flowers show that in the pin-eyed form the slender cylindrical style which supports the stigma is almost as long as the flower-tube; the style in the other form is much shorter, and only reaches halfway up the tube. The former is, therefore, designated the long-styled, the latter the short-styled, and the primrose is described as heterostyled or dimorphic, ordinary blossoms being homostyled or monomorphic. The point of special importance to notice, however, is that the stamens of the long-styled flower stand at a level which exactly corresponds with that of the stigma in the short-styled form; the stamens of the latter, in like manner, are on a level with the stigma of the long-styled flower.

These two forms of primrose had long been known, but their significance was never understood until explained by Darwin in his paper "On the two forms or dimorphic condition in the species of Primula, and on their remarkable sexual relations," published in 1862. Since that time Scott, Hildebrand, Müller, and others have repeated and extended Darwin's experiments on dimorphic flowers, confirming his conclusion that the two forms are adapted for mutual cross-fertilization.

Arrangements exist in many blossoms which secure the transference of the pollen to the exact part of an insect's body in one flower which is most likely to touch the stigma of the next flower visited by the insect, and the floral mechanism for this purpose often attains a remarkable degree of precision. The dimorphic condition might almost be described as a contrivance of the same kind. The salver-shaped corolla of the primrose is evidently fashioned in relation to the visits of insects; its broad limb, or upper horizontal portion, furnishes the attractive, coloured surface which renders the flower visible from a distance; it also offers a convenient landing-stage on which the visitor can rest while dipping its proboscis into the flower-tube. Short-lipped and otherwise undesirable

guests are prevented from reaching the nectar by the depth of the corolla-tube; its small diameter, too, makes it impossible for any insect to rifle the flower without touching the stigma and anthers. Contained in the base of the corolla-tube, the nectar is reserved for bees and butterflies having a slender proboscis long enough to reach to the bottom of the flower. A visitor alighting on a long-styled flower thrusts its proboscis down to the bottom of the corolla-tube; the middle part of the proboscis comes in contact with the anthers placed in the middle of the tube, and is coated with pollen. Should the insect next visit a short-styled flower, the pollen-dusted part of the proboscis, when inserted into the tube, is level with the stigma, and some of the pollen is almost certain to adhere to its viscid surface. At the same time, the basal part of the proboscis is dusted against the anthers situated at the top of the tube, and this pollen will be transferred to the stigma of the next long-styled flower which the insect happens to visit. By conveying pollen on different parts of its proboscis, an insect will thus constantly fertilize the long-styled flowers with pollen from the short-styled ones, and *vice versâ*. The crossing of the two forms in the manner described, which is the most natural result of insect visitation, Darwin distinguished as "legitimate"; the fertilization of a flower of either form with pollen from a flower of the same form, he termed "illegitimate crossing." He found, on artificially fertilizing the flowers, that the legitimate method was much more productive than the illegitimate—the average numbers of seeds being in the proportion of 100 to 54. Seeds resulting from illegitimate unions were, moreover, smaller than the others, and gave rise on germination to inferior seedlings. Convincing proof was thus furnished that the long and short-styled flowers of Primula are adapted for reciprocal cross-fertilization. This result has been confirmed by several investigators, but it is well to remember that it is deduced from averages, and that these, when analyzed, offer certain anomalies for which it is not easy to account in the present state of our knowledge. The figures obtained by experiments on different plants vary a good deal; nevertheless, the broad fact is established beyond question that the maximum fertility, as shown by the number and size of the seeds, is only obtained when dissimilar flowers are intercrossed in the way this would naturally be accomplished by an insect visiting the flowers.

The common primrose, cowslip, oxlip, auricula, polyanthus and many other primulas, including the common table plants *P. sinensis* and *P. obconica*, are all dimorphic. Our illustration is taken from the last-mentioned species. The water-violet (*Hottonia palustris*) is another of the Primulaceæ with dimorphic flowers; these were artificially fertilized by Herman Müller, and his results agree with those obtained in the case of Primula. Taking the result of legitimate fertilization as 100, the efficiency of the illegitimate mode would be represented by 65·5; of intercrossing flowers belonging to the same individual plant by 5·6; and of self-fertilization, or the impregnation of flowers with pollen from their own stamens, by 14·4 per cent. Some of the gentian order also bear dimorphic flowers. The beautiful white spires of blossom with which, in May, the bog-bean (*Menyanthes trifoliata*) enlivens our marshes, consist of long and short-styled flowers. The curious fact is recorded by Warming, that in Greenland this plant has become homostyled. Another of the gentian family, the centaury (*Erythræa centaurium*) blooming towards the end of summer, is, as I have observed, at least occasionally dimorphic. The purple-flowered flax (*Linum grandiflorum*), a common garden annual which must be known to most of our readers, is heterostyled; its flowers are remarkable as being absolutely barren when fertilized in the illegitimate manner. The lungwort (*Pulmonaria officinalis*), one of the borage order, and the buckwheat (*Polygonum fagopyrum*) may also be mentioned as examples of dimorphism. The order Rubiaceæ, of which the woodruff may be taken as a



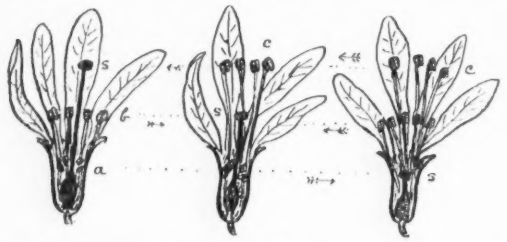
Dimorphic Flowers of Primrose (*Primula obconica*.) A, Long-styled form, with small pollen and large stigmatic papillæ. *a*, anthers; *s*, stigma. B, Short-styled form, with large pollen grains and small papillæ. *n*, insect's proboscis dusted in B, *m*, ditto in A. Pollen and papillæ highly magnified.

type, is, however, the richest in dimorphic species; these are all foreign, and several of them, though dimorphic in form, really have the sexes completely separate, the short-styled flowers having become male, and the long-styled ones female.

Great as is the interest attaching to the dimorphic class, certain other plants, which produce three different sorts of flower, excel them. The purple loosestrife (*Lythrum salicaria*), which grows in this country both wild and cultivated, is a typical example of this trimorphism. Its dissimilar flowers are borne, as in the dimorphic class, on separate plants, and are distinguished as short-styled, mid-styled, and long-styled. Each variety has two sets of stamens differing in height, the anthers being placed at levels corresponding to the stigmas of the other two forms; the short-styled flower has medium and long stamens, the mid-styled long and short stamens, and the long-styled short and medium stamens, as shown in the accompanying figures. As the long and medium stamens of the loosestrife project beyond the flower, they are more likely to come in contact with the body than with the proboscis of a visitor. The bee *Cilissa melanura* shows a singular partiality for the loosestrife, and confines its visits almost exclusively to flowers of this species. The dimensions of the insect accurately correspond with those of the flower, and H. Müller has noted that when engaged in extracting the nectar, it touches the shortest organs with its head, the intermediate ones with the ventral surface of its thorax, and the longest with the ventral surface of its abdomen. Darwin's numerous experiments on this plant conclusively show that for complete fertility it is essential that a stigma should receive pollen from a stamen of equal height. Of the eighteen possible modes of fertilization only six were found to be fully productive—viz., when the short-styled form was pollinated from the short stamens of the mid or long-styled flowers; when the mid-styled was pollinated from the medium stamens of the long or short-styled blossoms, and when the long-styled was pollinated from the long stamens of the short or mid-styled flowers.

Upwards of twenty species of Lythrum are known to be heterostyled, but a much larger number have flowers of the ordinary form. The genus Oxalis also contains numerous trimorphic species. The wood sorrel of our plantations, with whose pretty heart-shaped leaflets and pinkish white flowers our readers must be familiar, is homomorphic, but several closely allied exotic species bear three kinds of flower. One species of Oxalis is frequently met as an accidental introduction in greenhouses; the lengths of the styles and stamens in its different flowers are delicately

adjusted with a degree of accuracy which might well be described as mathematical. Pontederia, an American aquatic, is remarkable as affording an example of a trimorphic monocotyledon. Epigæa, one of the heath



Trimorphic Flowers of Loosestrife (*Lythrum salicaria*). *a* short, *b* medium, *c* long stamens; *s*, stigma.

order, attains, however, the highest degree of heteromorphism known. This plant, according to Asa Gray's description, is tetramorphic, producing four different sorts of flower, with styles and stamens of four different dimensions.

Heterostyled flowers differ not only as regards the length of their stamens and pistils, but in other respects as well. Their corollas sometimes differ considerably in size; short-styled flowers commonly produce larger pollen grains, and the stigma of the long-styled flower is larger and beset with longer papillæ than that of the short-styled blossom. From these differences it has been inferred that dimorphic species are on the way towards becoming dicœcious; in other words, are tending towards a complete separation of the sexes, a condition exemplified in the nettle, willow, poplar and many other plants. Long-styled plants have been shown to be more prolific than the others, whether the fertilization be legitimate or illegitimate; the intercrossing of two short-styled forms is, on the other hand, characterized by remarkable and, in some cases, absolute sterility. This circumstance has been held to indicate that the pistil of the short-styled form has undergone partial degeneration, but a strong objection to this view is the fact that the short-styled flower generally excels the other in its capacity for self-fertilization. In several experiments the short-styled flowers were found to yield abundance of seed when fertilized with their own pollen. The mid-styled form of Lythrum is the most fertile both in legitimate and illegitimate unions, but it is entirely unproductive with pollen from another mid-styled flower. The longest stamens of loosestrife have the largest pollen grains, their colour being green; the pollen of the short and medium stamens is yellow. Its stigmatic papillæ differ in a manner similar to those of dimorphic species.

The results of artificial fertilization fluctuate very much; Hildebrand, for example, found the lungwort completely sterile with its own pollen and with that from a flower of the same form. The long-styled variety of this plant Darwin, on the other hand, found highly productive, even when illegitimately fertilized, and he also obtained a number of seeds as the result of self-fertilization. If this discrepancy arose from Hildebrand's plants being kept indoors while Darwin's were grown outside, it would appear to show that the capacity of forming fertile unions is a character subject to great variation and liable to be affected by alterations in the external conditions under which plants are grown.

A noteworthy fact, revealed by investigations on this subject, is that flowers of the same species when illegitimately united behave in exactly the same manner as do two distinct species when crossed. If pollen from a different species be applied to a flower's stigma, and its own pollen be afterwards placed on the same stigma, the latter is so strongly prepotent that it generally arrests the effects of the foreign pollen. In heterostyled flowers legitimate pollen is also strongly prepotent over illegitimate when placed on the same stigma. The effect of illegitimate fertilization was found to be completely neutralized by the application, twenty-four hours later, of legitimate pollen. Again, the offspring of illegitimate unions admit of being crossed in a legitimate manner, but when this is done, instead of the complete fertility which we should expect, such unions exhibit marked and, in some cases, absolute sterility.

There is thus the closest analogy between these illegitimate plants and hybrids. As regards fertile union, a short-styled primrose stands related to another flower of the same form, very much as it does to a flower of a different species altogether, and an illegitimate plant derived from the crossing of two similar primroses is, as regards reproduction, to all intents and purposes a hybrid. The sterility of hybrids was long regarded as an unfailing test of species; the phenomena of dimorphism and trimorphism, however, forbid us to regard this as a safe criterion of specific distinction.

The varying degrees of fertility disclosed by investigations of this kind, lend countenance to the theory advanced a few years ago by the late G. J. Romanes to explain the origin of species. It is not every variation, as he pointed out, that can give rise to a new species, for natural selection only accounts for the preservation of useful characters. Allied species are commonly distinguished by characters which are of no physiological importance whatever. Further, when a new variation has once arisen, there is nothing in natural selection to prevent its disappearing again through intercrossing with the parent stock. To obviate these difficulties, Romanes brought forward his supplementary theory of physiological selection, or the segregation of the fittest, which attributes the origin of a new species to the appearance of a variety which is sterile with the parent form, although fertile when intercrossed with others of its own variety. Such sterility, when it arose, would prove a barrier against retrogression.

Since their near allies are all homomorphic, the ancestral forms of heterostyled plants doubtless bore but one kind of flower. The styles and stamens of many flowers are subject, especially under cultivation, to vary much in length. Selection by insects would, however, tend to fix the stamens and styles at the proper height, and the flowers might thus ultimately become dimorphic or trimorphic. As heterostylism occurs in families which have but little affinity with each other, the arrangement has in all probability arisen independently in different groups.

Cross-fertilization is in many flowers promoted by dichogamy; the stamens and stigmas do not mature simultaneously, but the flowers are alternately male and female. Where this arrangement exists, two insect-visits are required for the proper fertilization of each flower. Over these, heterostyled plants have this advantage, that one insect-visit suffices both for the pollination of the stigma and the removal of the pollen. Where the proper insects are scarce, this advantage may become of some importance. It is right to mention, in conclusion, that Henslow takes exception to some of Darwin's deductions regarding the advantages of cross-fertilization, and points out that under certain circumstances, self-fertilization appears to be quite as effectual. Fresh experiments would seem to be required to ascertain precisely the conditions under which each method is adopted. Henslow's views are to a certain extent, however, in accord with Darwin's;

for he too holds that as at present constituted, most flowers do derive benefit from the intercrossing which insects accomplish. The question at issue does not, therefore, seriously affect any of the statements advanced in the present paper.

BARON VON TOLL'S EXPEDITION TO THE NEW SIBERIAN ISLANDS.

By Carl Siewers.

In 1889, the Imperial Russian Academy of Sciences had received from the well-known Siberian merchant, Mons. Sannikoff, information to the effect that the body of a mammoth had been discovered under the seventy-third degree of latitude, on the Balakhna River, which flows into Khatanga Bay, and Baron Toll was at once invited to take the leadership of an expedition for the investigation of the discovery. The bad state of the Baron's health compelled him, however, to decline the offer, and Mons. Chersky was sent out to make collections of post-tertiary mammals in the far north-east, on the rivers Yana, Indighirka, and Kolyma. After Chersky's untimely death, the proposal to start for the Khatanga was renewed to Baron Toll, and it was decided that he should not only examine the mammoth find—which, after all, might prove to be of no importance—but also make a general exploration of the very little known Anabar region. He left St. Petersburg on January 2nd, 1893, in company with Lieut. Shileiko, who undertook the topographical and astronomical work of the expedition, as well as the magnetical observations.

After a short stay at Irkutsk, they travelled to the Aldan, whence they proceeded in reindeer sledges. The Verkhoyansk range was crossed by the Tukulan Pass, five thousand feet high, and from Verkoyansk the explorers went westwards, across the Omoloi Mountains, to Kazachiye, which was reached on April 8th. Talking there with his old acquaintances, Baron Toll came to the conclusion that he would be able to make, in this same spring, an excursion to the New Siberian Islands, travelling in dog-sledges on the ice. He started immediately after Easter, with Mons. Sannikoff and several men, to visit the place where the mammoth body had been seen, one hundred and seventy miles north-east of Ust-Yansk. Four days later they began operations, and in two days the men, who had already won some experience in this sort of work during a previous expedition, had reached the mammoth.

The Expedition on the frozen ocean between the Island of Ljachow and the mainland, with the mountains of the latter in the distance.

However, Sannikoff's hopes were not fulfilled. Only small pieces of the skin, with the wool attached, parts of the extremities, and the lower jaw of a young mammoth were unearthed. The skull had long since been broken, and the tusks had been taken away. These relics were all lying in recent alluvial sands, deposited by the Sanga-Yuryakh River, which had washed them out from the underlying post-tertiary beds. It was, therefore, decided to return later to the spot when the snow would be gone, and in the meantime to pay a visit to the islands.

On May 1st, the two explorers, accompanied by one Cossack and three Lamutes, left the mainland and landed on the south coast of the Malyi Lyakhov Island. Work was begun at once, and at the very start Baron Toll came across the interesting fact that under the perpetual ice, in a sweet-water deposit, which contained pieces of willow and

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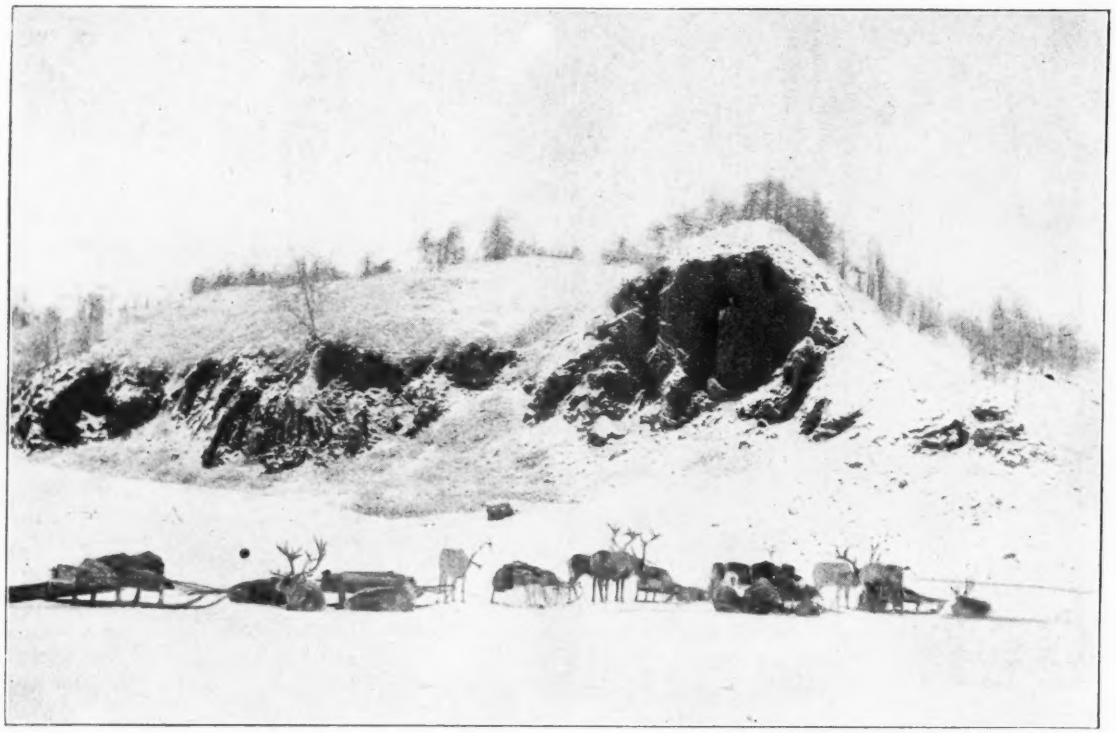
bones of post-tertiary mammals (the mammoth layer), were complete trees of *Alnus fruticosa*, fifteen feet long, with leaves and cones. It was thus evident that during the mammoth period tree-vegetation reached the seventy-fourth degree of latitude, and that its northern limit was at least three degrees further north than it is now. The importance of this discovery is self-evident. Moreover, at this spot, as well as during further exploration, especially on Kotelnyi Island, the origin of the thick layers of ice which are seen everywhere under the sweet-water post-tertiary deposits of the New Siberian Islands could finally be settled. It was obvious that this ice did not originate from snow; for it has everywhere a granular structure, and must thus be considered as originating from the ice-sheet of the glacial period.

As to the present conditions of climate and animal life, they appeared under quite a different aspect from what they were in 1886. In that year, even on May 13th, the temperature was 6° Fahr.; while in 1893 it was raining on May 6th on the Great Lyakhov Island. True, this was the first rain of the season, and it was followed by snow-storms, but it was a forerunner of summer. The first winged guests made their appearance on Kotelnyi Island in the middle of May; the gulls taking the lead, then the geese, followed by turkans, skuas, and others. The latter found plenty of food in the mice, the only winter inhabitants of the islands. The mice displayed a feverish activity; some of them migrated from one island to the other, others migrated to the continent, while others, again, came from the continent to the islands.

On the return journey, frosts became less and less frequent, and the travellers had to drag their sledges themselves, as the ice hummocks, which are all cemented together by hard snow during the winter, were now loose and surrounded by water. Notwithstanding these difficulties, the return journey of one hundred and fifty miles was performed without accident, and all the instruments and collections were safely landed on the mainland on June 8th.

The second part of the journey, over the *tundras* and across the Khara-ulakh range to the Lena, was accomplished on reindeer-back, the expedition dividing into two parties at Aijergaidakh, as Baron Toll wished to revisit the mammoth remains. Now that the snow had gone, it was seen that only parts of an incomplete corpse were buried at this spot, and no further relics could be unearthed.

The ride on reindeer-back from the Svyatoi Nos to the Lena, a distance of eight hundred miles, proved that the *tundras* can be crossed at any time of the year if the traveller rides a good reindeer, which easily crosses the most swampy places, but, in addition, a *vyetka*—that is, a boat for crossing rivers, made out of a poplar tree, or of three larch planks—is useful. During this journey the two explorers had again an opportunity of making a fuller acquaintance with the peculiarities of the Polar climate. In July, on the shores of the Arctic Ocean, in lat. 72°, the temperature was 93° Fahr., and the sky remained quite clear all the time.



The Expedition in reindeer sledges on the River Anabar, lat. 72° N.; larch trees in the background at the forest limit.

After having crossed the Khara-ulakh range in two separate parties, they met together at Kumakh-sur, where they took a boat and explored the Lena and its delta.

On August 24th the expedition started westwards in a long caravan of nearly fifty reindeer, in order to explore a region which had not been visited by a European for more than one hundred and fifty years, since the times of Lapteff and Pronchishcheff. They had only one guide, a

Dolgan, and five Yakuts. The chief aim of the expedition, the bay of the Anabar, was reached on September 2nd, at Cape Buskhaya. Good weather set in, and for a full month they had a succession of bright, warm days. Lieut. Shileiko was thus enabled to make a fundamental survey of Anabar Bay, as well as of the Anabar River, as far as the mouth of the Uja, at the limits of tree-vegetation—that is, for a distance of two hundred and seventy miles. At the same time the high crags of the bay and river (attaining in places heights of three hundred feet) afforded Baron Toll the possibility of obtaining a full picture of the geological structure of the region, and he gathered a rich collection of the fauna of the lower chalk deposits, of which the plateau between the Lena and the Anabar, and probably also the country further north, up to the Khatanga, is composed. In the five different horizons of the lower chalk, which he thus investigated, he found all the Mesozoic fossils, and especially the ammonites of doubtful age, which had previously been found in North Siberia, either isolated or in boulders, and thus he was enabled to ascertain their proper place in the succession of fossils of that age.

After having completed their work on the Anabar, the explorers, instead of returning by the already known route to Bulun, took a new one, and connected their surveys with Dudinskoye on the Yenisei. Baron Toll, having to return to Bulun for his collections, parted company with Lieut. Shileiko, who lost no time in moving westwards.

Meeting again at Khatangskoye, the two explorers started for their home journey, which they accomplished with remarkable rapidity. It took them but thirty days to reach Yeniseisk, and twenty-three days later they were at St. Petersburg.

The results of the expedition are encouraging. Over three thousand miles were surveyed, being based upon thirty-eight points, astronomically determined; nine months of meteorological observations in the *tundras* were noted; hypsometrical measurements along the whole of the route were made, while one hundred and fifty photographs and very rich collections of botanical, zoological and ethnographical specimens were obtained.

It should be added that Baron Toll was also to keep a good look-out for the *Fram* and the Nansen expedition, which, as originally settled, was to call, and even winter at the New Siberian Islands, but as no traces whatever were found of that expedition, it is concluded that Nansen found the sea so open to the north-east that he did not call, in order to avoid delay, but steered direct into the Polar pack, which he believes is to carry him across the Pole and south to Spitzbergen.

The two photographs accompanying the present paper were taken by Baron von Toll, and placed at the disposal of the writer.

NOTES ON A SOLAR PHOTOGRAPH.

By E. WALTER MAUNDER, *Hon. Sec., R.A.S.; President British Astronomical Association; Superintendent of the Physical Department, Royal Observatory, Greenwich.*

THE readers of KNOWLEDGE are indebted to M. Janssen, Director of the Meudon Observatory, for the fine solar photograph reproduced in the present issue. The original negative was taken on April 1st, 1894, and was then enlarged, for the special district shown, to a scale of one mètre to the solar diameter. This has been slightly enlarged further in the process of reproduction. The plate being too large as it stood for a page of KNOWLEDGE, it has been divided into two, but the relation of the two parts has not been otherwise disturbed. The upper and lower edges of the two are in the same straight line with each other, and the following edge of the one corresponds to the preceding edge of the other.

The first point of interest in the photograph, of course, attaches to the three considerable groups of spots, which, together, form indeed a very fairly typical area of disturbance; not one of the greatest outbreaks, but one of at least the second order of magnitude. On April 1st, the day in question, the total area of the three groups was 2360 millions of square miles, just one five-hundreth part of the entire visible hemisphere of the sun; the three separate groups registering 600, 1580, and 180 millions of square miles respectively. A comparison with photographs taken on the preceding and following days shows that the three groups were still on the increase on April 1st, though they were not far from their greatest development. This was reached on April 4th, after which a rapid decline set in.

As will be seen from the little sketch map given in Fig. 1, which shows the relation of the three groups to

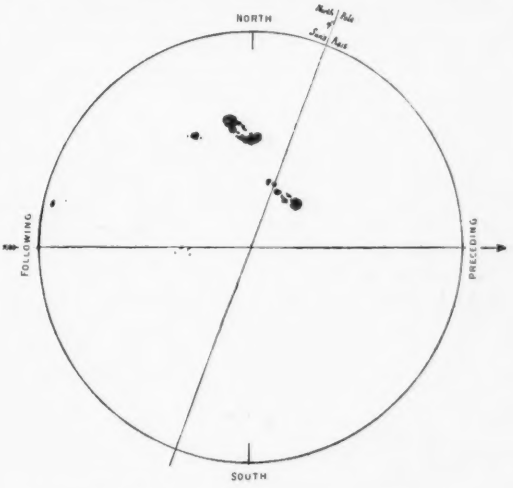


FIG. 1.—The Sun on April 1st, 1894; showing positions of the chief Spot-groups.

other spots on the sun and to the general disc, the western group was on the central meridian at the time when the photograph was taken. The groups are, therefore, shown at their best and fullest presentment to us, as well as when they had nearly attained their largest size.

The history of the three groups is of a very ordinary kind. Distinguishing them as "western," "northern," and "eastern" respectively, the western group was first seen as a number of somewhat small spots, closely packed together in an irregular cluster, and surrounded by a considerable mass of faculæ. By the next day the group had apparently lengthened out a little, an effect, however, due only to the diminution in the foreshortening. But by March 29th a real lengthening, as well as an apparent one, was evident, due to the motion forward of the leading spot, which was at the same time rapidly increasing in size. Thus from an area of 14 millions of square miles on March 28th, it had increased to 640 millions on April 4th, a growth of 626 millions of square miles in a single week. The forward motion in longitude had not lasted so long, coming to an end on April 2nd. The five days showed a motion of 4·5°, or 0·9° a day, equivalent

to nearly 7000 miles, or 300 miles an hour. It must, however, be always borne in mind that even moving at this tremendous speed it would take the spot four entire days to cross its own diameter when at its greatest extension. This kind of spot motion is, therefore, rather the development of the disturbance forward than the actual movement of the spot on the solar surface. The spot has seemed to move, *mainly* because its growth has been restricted on the following side, but has proceeded freely to the west and north and south.

Contrast with this growth and mobility that of the last spot of the group. With an area of 27 millions of square miles on March 27th, it extends to 31 millions on March 31st, and has shifted its position 0·1° in longitude in four days. Then the bright faculous matter surrounding it closes in upon it. It has shrunk to eight millions by the day of our photograph, and has disappeared by the following day.

This behaviour is most strictly typical of a large class of spot-groups. The actual commencement of the group was not witnessed in this case, as it took its rise in the unseen hemisphere. But it was evidently not more than two days old when first discerned near the east limit. The gradual change of the compact irregular cluster into the long straight stream by the forward rush of a single small spot, which grew as it advanced, whilst the spots in the rear remained almost motionless, is continually being witnessed, and the rate of advance is practically always the same—from 6000 to 8000 miles a day. Then, as with the present group during April 3rd—6th, there is a gradual swing back of the leader spot as the train of smaller spots which follow it die out. On April 5th, for example, the leader has receded 1·4° from its place on April 2nd, and is accompanied by but a single follower.

The condition in which the group was now seen is apt to be a stable one. In the present instance it was lost to sight at the west limb after April 6th, but a fortnight later was seen again at the east limb, still a well-defined circular spot, but little smaller in area to what it was on April 6th, in practically the same longitude, but having moved more than 2° towards the north in latitude. It remained steadily in this position without materially changing as to place, size or appearance. It reached the west limb for the second time on May 3rd, and was not seen again.

The eastern group, like the one we have just noticed, took its rise in the unseen hemisphere, but its regular outline and stability of position point to its being already an old spot when it first came into view on March 28th. Besides, its period of growth was already over, and a slow and steady shrinkage from an area of 225 millions of square miles to one of 126, was practically the only change it showed during this period of visibility. Occasionally one or two little acolytes were seen near it; there were three on April 1st, but these soon disappeared again. The group showed precisely the same features during its second appearance, the shrinkage still continuing, until, by May 4th, its place was entirely covered over.

The third and largest of the three groups, the one furthest to the north, showed by far the greatest activity, and furnished during much of its course an example of another class of spot stream from that afforded by the western group. Its commencement was quiet enough—a small solitary spot near the east limb on March 28th. Its area was about 33 millions of square miles, it had obviously not long formed, and it was surrounded by some bright but not extensive faculæ. Its development was very striking. It covered an area of 224 millions of square miles on March 29th, and three fresh spots had formed behind it. These at first lay nearly at right angles to the direction of the solar rotation, but speedily fused together, and tended to draw out in a line parallel to it. On March 30th the group consisted mainly of two fine composite spots, each showing several nuclei, and covered a total area of nearly 1000 millions of square miles. A double chain of very small spots united the two giants of the group. The increase continues on the succeeding days until April 3rd and 4th, when the total area reaches 1660 millions of square miles. After this the group begins to decay, and it proves the most short-lived of the three. Bright faculous matter begins to pour into the rear spot on April 5th, and by April 7th it is completely broken up. Simultaneously with this destruction of the following portion of the group the great leader spot has moved forward and northward with great rapidity, a movement it evidently continues whilst in the further hemisphere, for after its second appearance at the east limb on April 22nd it is found to have travelled more than 10° in longitude and 2° in latitude since April 5th. The leader, now reduced to a small circular spot of about 30 millions of square miles area, is all that remains of the great group, and ten days later the last remnants even of this have disappeared.

The great difference between the western and the northern groups lay in the fact that the growth of the former was chiefly confined to its leader spot, but that of the latter was divided nearly equally between the first spot and the last. It is in strict accordance with this circumstance that the elongation of the first group was due to the rapid motion forward of its growing leader; but that of the other to the motion apart from each other of its two end spots, the leader moving forward, the rear spot moving backward, a motion which continued so long as the growth of both was maintained. The break-up of the rear spot was at once answered by a check to its motion, and by an increase in the forward drift of the leader.*

Another striking feature of the northern group, and one intimately connected with its chief development in two directions, was that the disintegration of its two spots proceeded on the inner side; the front spot wasted on its following side, the rear spot on its preceding side. The outer edges of both spots were regular and well defined. This alteration is partly shown in the present photograph, but the process was better seen on the previous day, when the group was in a condition of more active change.

The three groups before us, therefore, though not of extraordinary size, presented several points of interest. There is yet another to which allusion should be made.

As I have had occasion to point out before ("The Great Sunspot and its Influence," Knowledge, May, 1892), it is by no means easy to make a satisfactory comparison between sunspots of what I have called the second order of magnitude, and magnetic disturbances. They may or may not be observed simultaneously. The present occasion was, however, one in which a considerable display of sunspots was coincident with a marked but not an extraordinary magnetic irregularity. As the accompanying trace (Fig. 2) will show, the declination magnet at Greenwich commenced to swing eastwards at about five p.m. on March 30th, and a set of oscillations commenced, of no great rapidity but of considerable length, which, by the following midnight, had reached a point nearly a degree removed from the mean place. The oscillations which followed tended to bring the magnet back to its normal position,

* A rotation period of 25·38 days was assumed in each case. The use of either Spoerer's or Carrington's values for the special latitudes concerned would alter the rates of motion given in the above remarks, but would only account for a small portion of the change of longitude.

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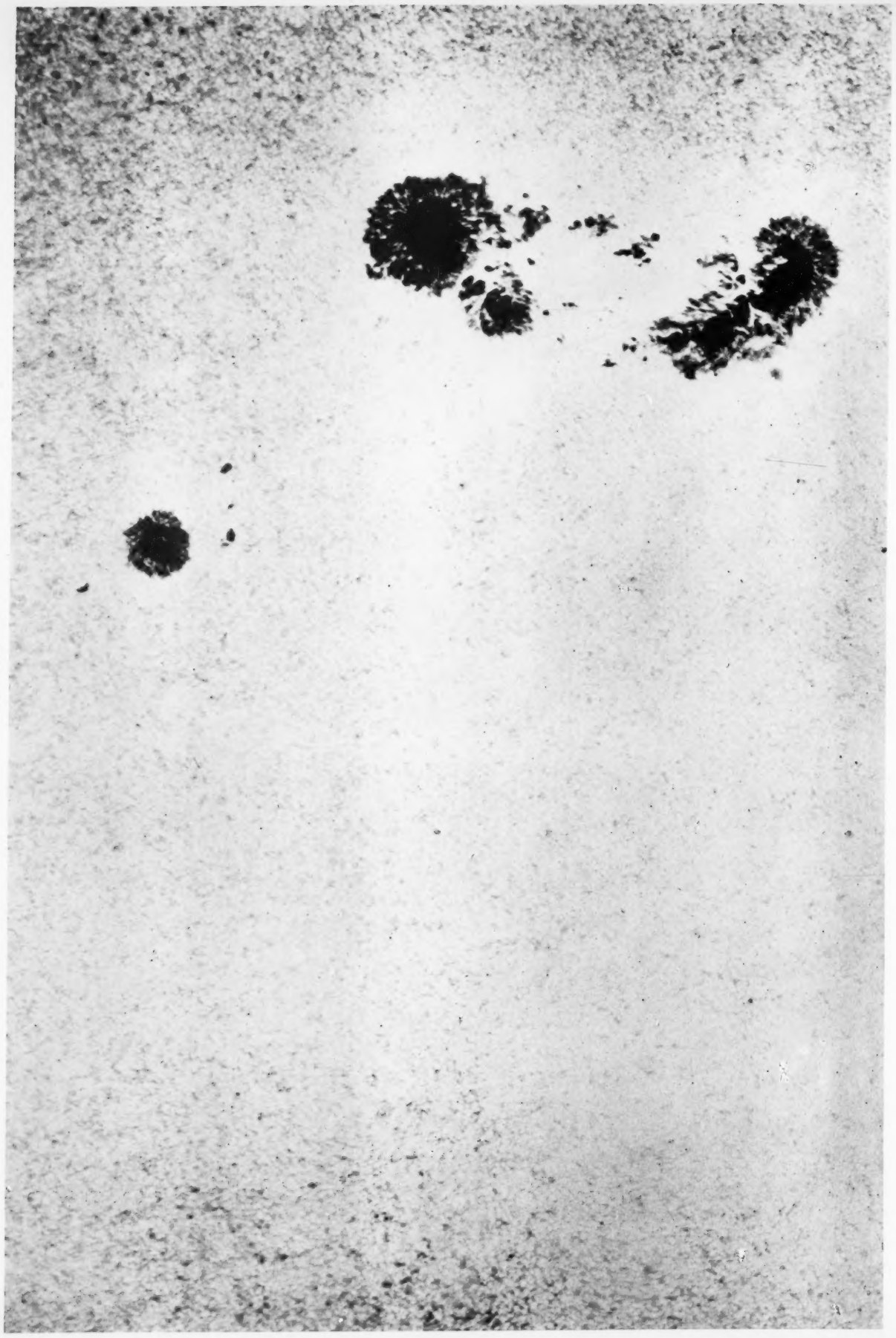


FOLLOWING.

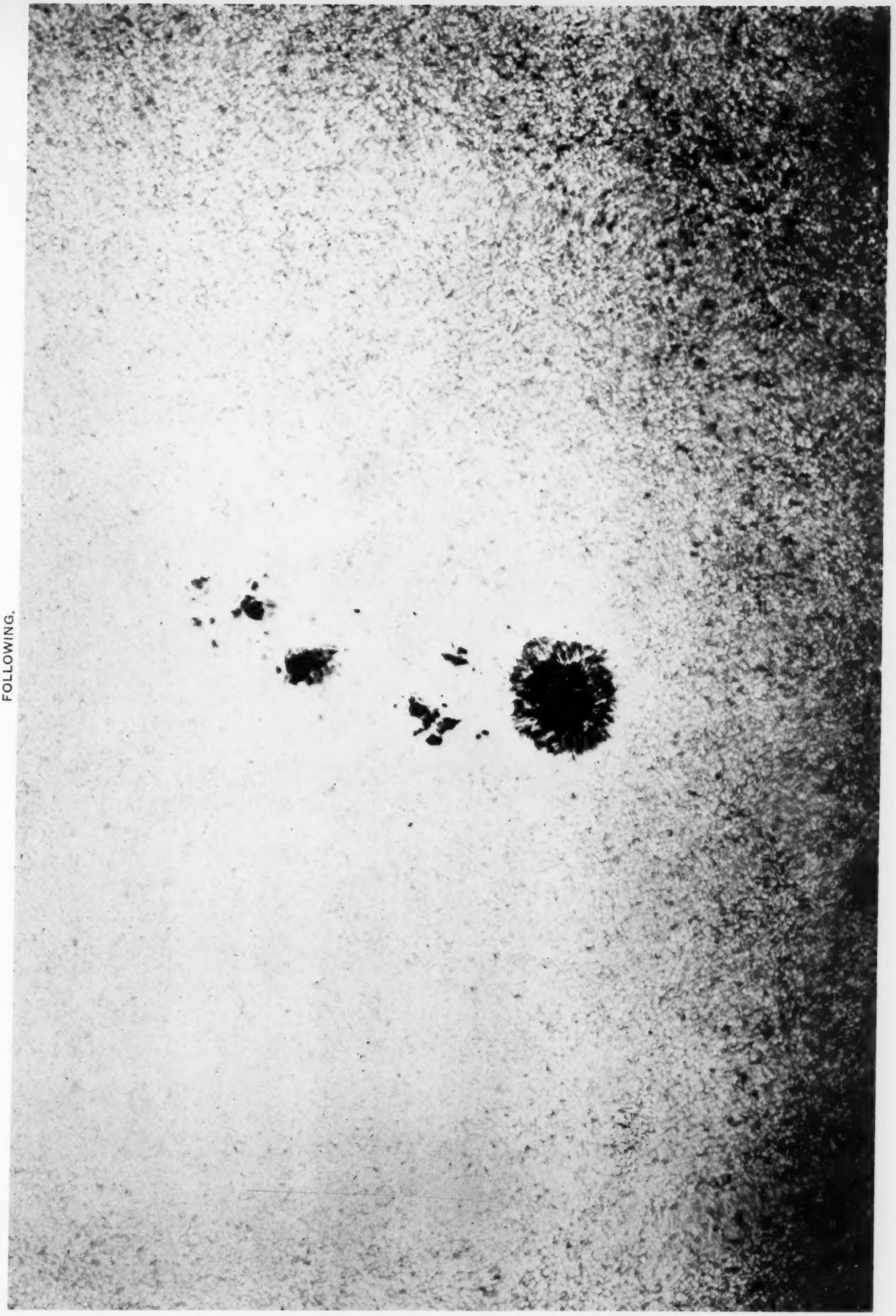
PRECEDING.

GROUP OF SUNSPOTS, APRIL 1st, 1894.

Enlargement, on a scale of about three feet to the solar diameter, by M. JANSSEN, from a Photograph taken by him at the Meudon Observatory.

Direct Photo Engraving Co., 9, Baraabury Park, N.

NORTH.



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Direct Photo Engraving Co., 9, Barnsbury Park, N.

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and by five a.m. on March 31st, the disturbance was practically over. A second, but much slighter, set of tremors began the following evening, but ceased at midnight. A comparison with the traces of the magnetic storm which accompanied the great spot of February, 1892 (KNOWLEDGE, May, 1892, p. 92) will show that there was nothing on the present occasion to rival the short, swift vibrations of the earlier disturbance, nor did this storm begin by that sharp instantaneous twitch which was seen in that of 1892—a twitch which is a well-marked and most truly typical feature of first-rate magnetic disturbances.

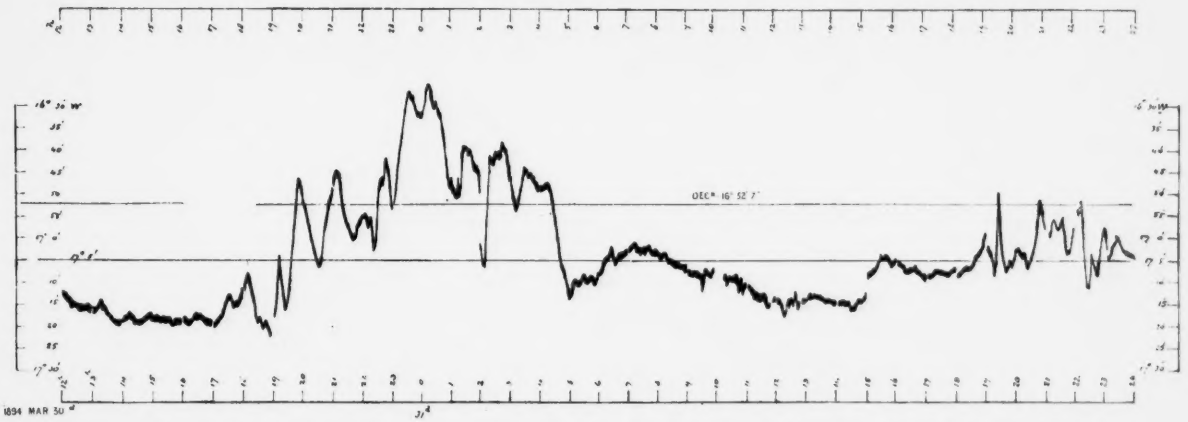

FIG. 2.—Photographic Trace, showing the movements of the Declination Magnet at Greenwich, March 30th and 31st, 1894.

The coincidence, therefore, in the present case is of a much less convincing character than in those of the giant spots, and if it stood alone but little could be made of it; but taken in connection with the evidence which the greatest spots and storms supply, it tends to confirm the view that the solar magnetic influence, whether direct or indirect, is not associated with any precise position of a spot on the disc, but is greatest when the spot is near the central meridian. For the instances given in my paper, alluded to above, referred mostly to magnetic storms which had taken place when a great spot had just passed the central meridian. The present is a case in which the storm took place just before the most important visible group reached it.

Passing from the sunspots, the next remarkable feature of our photograph is the contrast in brilliancy between the centre of the field and its edges. Round the northern group, and stretching far to the south in one vast sheet, is a mass of intensely luminous matter, compared to which the ordinary photosphere as seen towards the edges of the photograph looks dim and dark. It cannot be questioned that this matter is at once brighter and higher than the general photosphere. The way in which it invades, and overhangs, and in some cases apparently hides the members of the western and northern spot-groups is irresistible proof of its greater height.

This fact is of some importance in the light of a discussion which has recently been revived by the Rev. F. Howlett, F.R.A.S., as to whether or no sunspots are cavities. It is well known that Prof. Wilson, nearly one hundred and twenty years ago, was led to conclude, from watching the behaviour of a large, well-defined spot, that this was their true form. As the spot approached the limb, and was therefore seen strongly foreshortened, the penumbra on the side remote from the limb narrowed faster than that on the other side, and finally disappeared, being hidden by the lip of the spot on the side nearer the centre of the sun. Further foreshortening subjected the umbra to a like encroachment, until only the penumbra on the side nearest the limb remained in sight.

To a certain degree every solar observer will support Mr. Howlett's attack on the theory which Prof. Wilson based on this observation. There is no question nowadays of the body of the sun being dark; neither can we suppose that the depth of even the deepest spot bears any appreciable ratio to the solar radius, or even to the diameter of the spot opening itself. If sunspots are cavities, then, relatively to their area, they are exceedingly shallow cavities, and we have no right to expect that the foreshortening of a spot near the limb will do much more than apparently slightly misplace the central nucleus.

The examination of a photograph like the present appears to me to clearly demonstrate that, however relatively shallow, the spots are still actual depressions. This bright faculous matter so clearly overrides both penumbra and nucleus, both in the central spots of the northern group and in the following spots of the western, that its greater elevation cannot be challenged. Seeing, then, that we have four distinct regions of different intensity, this bright faculous matter, the ordinary photosphere, the penumbra of the spots and their nuclei, of which the brightest is manifestly the highest, so that, to take the northern group for example, the spots which it surrounds are evidently depressions below its level, is it not reasonable to conclude that the dark nucleus is a depression below the less dark penumbra that surrounds it, and the penumbra a depression below the brighter photosphere around it?

The difficulty of arriving at a conclusion as to the true form of sunspots from observation of the Wilsonian phenomenon seems to me to have been scarcely grasped. In the first place, on any reasonable hypothesis as to the average depth of a spot, the Wilsonian effect must always be but slight. Next, the instability of the vast majority of spots is so great, that the fact of the nucleus being central when the spot is in the centre of the disc, scarcely even furnishes a presumption that it will be so five or six days later. Then the effect of refraction in the solar atmosphere, concerning the amount of which we are necessarily total ignorant, would tend to mask the Wilsonian phenomenon. But above all, if the darkness of a sunspot be due to absorption, and if the spot be a depression, absorption will be greatly increased as the

spot approaches the limb. The penumbra on the side of the spot remote from the limb would, therefore, tend to be hidden, as Prof. Wilson pointed out. The nucleus would not only be made darker, but would suffer a fictitious extension in the other direction. In short, the actual effect to be expected on this hypothesis is not the mere hiding of the penumbra and nucleus on the side furthest from the limb. It would be a threefold effect; the spot, as a whole, would be darker, the umbra would be relatively enlarged, and the contrast between the photosphere and the spot on the side furthest from the limb would be increased.

So far as my own observations go, only one of these three effects is perceived, and that not very markedly—the sharper contrast at the inner edge of the spot. It seems to me clear, then, that we cannot look upon a sunspot as merely an absorption effect.

That it is partly so, the spectroscope proves beyond a doubt. I have been quite unable to follow those observers who can find no broadening of the Fraunhofer lines in a spot spectrum. There are, indeed, wide belts of the spectrum where the lines broadened are few, and the broadening slight. But from C to D, and near the *b* lines, I cannot understand how the effect can be overlooked.

Still, when the entire additional broadening seen throughout the whole spectrum is allowed for, it accounts for but a very small fraction of the loss of light in the spot. Gaseous absorption there unquestionably is, but it fails to account for the darkness of the spot.

We have, however, come to recognize the existence round the sun of a vast quantity of dark solid particles—dark, at all events, as compared with the photosphere. It is to this solar "dust" or "smoke" that the chief part of the rapid falling off of the sun's light near the limb is due. If the darkening of the spot were due to this dust filling up the hollow of the spot, then we should have a general darkening throughout the spectrum, as is most certainly the case, but should also have the threefold effects described above, but which are much less obvious than they should be.

It seems conclusive, then, that the main cause of the darkness of a spot is not increased absorption—either selective, as from gases, or general, as from solid particles. It is chiefly due to diminished radiation.

The light of the photosphere has been ascribed, since Mr. Johnstone Stoney's paper of nearly thirty years ago, to the condensation of carbon. There is a certain level where the uprushing streams of glowing gases from the centre of the sun become so far cooled by expansion and radiation as to condense carbon, and possibly silicon, into the form of clouds of dazzling brilliance. For the most part, no doubt that level remains pretty constant. It must do so, indeed, for the greatness of the sun's attractive force will render the diminution of atmospheric pressure for every mile of ascent very rapid.

The exception is seen in such a luminous region as we observe in the midst of the northern spot-group. Here there has evidently been an uprush of gases, so strongly heated, and rising with such speed, that condensation does not take place until a much higher level than usual is attained, and there it is both sudden and complete. These brilliant clouds rise above much of the dust layer, no doubt, and appear the more brilliant on that account, as they escape some of the dimming which the dust layer causes.

With the uprush there is necessarily associated a region of diminished pressure, a region of downrush into which no small amount of this darker, colder solid matter is drawn. Sometimes we have the uprush coming up nearly straight from below. In this case the corresponding depressions tend to be pretty evenly balanced, one in advance of, the other following the uprush. We have then a group of spots like the northern one, essentially a pair of spots. In this case, as the strength of the outburst grows, the two depressions at either end are forced apart as they widen. In the case of the western spot-group the outburst seems itself to have had a strong forward motion. Hence the accompanying depressions were mostly confined to a single spot, which moved rapidly forward as it grew.

We may look, then, upon the nucleus of a spot as being relatively dark, partly because seen through an increased depth of absorbing gases, partly and to a much greater extent because the spot cavity is filled with comparatively cool solid particles, and partly, and perhaps chiefly, because the floor of the spot lies below the level at which gaseous carbon suffers condensation. A spot is thus a region of diminished radiation, as well as of increased absorption. It is a hollow, but so shallow relatively to the vast bulk of the sun as almost to justify us in speaking of it as a surface stain. It is a hollow, but not an empty one, nor filled merely with gases. It is filled with matter of the same nature as that which causes the limb of the sun to look so much less bright than the centre—that is to say, in all probability, with finely divided solid particles that are far advanced in cooling.

ANOTHER SPECTROSCOPIC BINARY STAR.

By Miss A. M. Clerke, *Authoress of "The System of the Stars" and "A Popular History of Astronomy during the Nineteenth Century," &c., &c.*

It seems that δ Cephei is to be added to the list of these wonderful objects. The result is not altogether unexpected. Successive discoveries, and especially that of the duplicity of β Lyræ, led up to it. Nevertheless, the actual revelation of the fact is of profound interest. It throws open new views, modifies old ones, and must powerfully stimulate research into the conditions of stellar variability.

The light-changes of δ Cephei were detected by Goodricke, of York, in 1784, and have since been attentively watched. They are accomplished, on the whole, with exactness and punctuality. Argelander stated in 1848 (*Astr. Nach.*, No. 624) that, during seven years of constant observation, he had perceived no break in their uniformity. Schönfeld concluded in 1876 (*Zweiter Katalog*, p. 49) against the presence of any genuine irregularities. The light-curve, however (as the accompanying figure shows), is by no means smooth or symmetrical. The rise from 4·9 to 3·7 magnitude is executed in 1d. 13·6h., or in just one-third of the entire period of 5d. 8·8h., the decline being, moreover, interrupted by a stationary interval beginning about sixteen hours after maximum. This curious halt, which almost suggests an attempt at a second maximum, and is common to many variable stars, is vouched for, in the case of δ Cephei, by both Schönfeld and Argelander, but does not appear in Prof. Oudemans' curve representative of its phases. Perhaps it is less emphasized at some times than at others. The range of variability is sensibly constant. Schmidt recorded, it is true, one completely abortive maximum. The increase of brightness due on May 6th, 1868, was barely indicated (*Astr. Nach.*, No. 1745). But this alleged failure, since it rests on the testimony of one, albeit a very competent observer, suggests illusion. The character of the star for accuracy in variation is otherwise unimpeached.

It was given the first place on M. Bélopolsky's list of

naked-eye variables to be investigated with a new spectrographic apparatus fitted to the thirty-inch Pulkowa refractor in the summer of 1894 ; and he obtained, in August and September, a series of thirty-four photographs

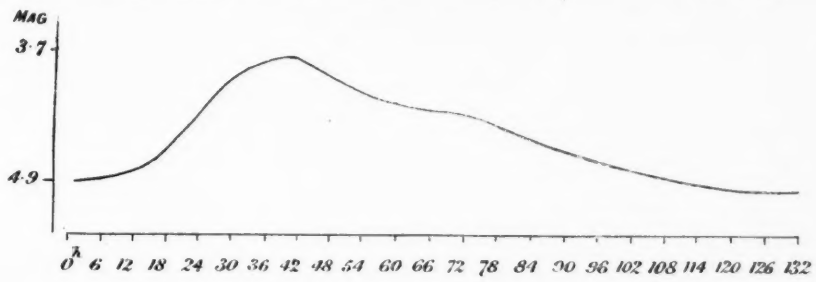

Fig. 1.—Light-Curve of δ Cephei (Schönfeld).

of its dispersed light, each plate being impressed besides with spectra for comparison of iron and hydrogen. Their examination showed at once the progress of orbital motion in a period indistinguishable from that of the luminous change. It was, however, betrayed, not by the alternate separation and closing-up of two sets of lines, but by the swinging to and fro of a single set. The star thus circulates, like Algol, round a partially or totally dark body. M. Bélopolsky has calculated its orbit by a method invented by Dr. Rambaut (*Monthly Notices*, LI., 316), and improved by M. Lehmann-Filhés (*Astr. Nach.*, No. 3242). It proves to be so considerably eccentric that the star is three times nearer to the centre of gravity of the system at its furthest retreat from, than at its nearest approach to it ; and the long axis of the ellipse is turned almost directly towards the earth, with the apastron at the hither side. Half this axis (that is, the mean distance), multiplied by the cosine of the inclination to the visual ray, is 800,000 English miles in length. But since the inclination is undetermined, and perhaps undeterminable, this is no more than a minimum estimate. If the orbital plane, for instance, made an angle of 60° with our line of sight, it should be doubled. Nor is any reason apparent why the angle should not be even greater than 60°. Where an eclipse may be supposed to occur, the case is different. Then the inclination must be approximately zero. Half the sum of the measured velocities of Algol, when moving directly towards and away from the earth—in other words, as it passes through the nodes of its orbit—thus represents neither more nor less than its actual velocity of circulation.

In δ Cephei, none of the symptoms characteristic of an eclipse are visible. The shape of the light-curve is scarcely compatible with its occurrence. It shows no abrupt hollow, no prolonged high-level of full brightness. The maximum, on the contrary, is no sooner reached than a gradual and indecisive descent towards minimum begins. The former is accordingly much more sharply defined than the latter. So that the conditions imposed by the eclipse-hypothesis, far from being complied with, are reversed. It would indeed be impossible to devise any form of occultation capable of explaining the entire variation of δ Cephei ; none even tending to simplify, or usefully to supplement other causes of change. The introduction of geometrical obscurations appears, then, to be superfluous and misleading.

When they really occur they are unmistakable. Algol-stars have their character writ large enough for the quickest runner to read. Rigid tests can, moreover, be applied. Eclipses can only take place when the bodies concerned are moving across the line of sight—that is, at periods of spectroscopic immobility. Prof. Vogel has shown that this requirement is *not* conformed to at the minima of β Lyræ, which cannot, therefore, be due to the alternate concealment of one of the star's lustrous components by the other. And M. Bélopolsky's data regarding δ Cephei are, as they stand, equally conclusive. In a system like that of Algol, in which a bright star passes behind a dark one, radial movement must evidently be recessional previous to the eclipse, cease altogether during its progress, and reverse its direction when the eclipse has terminated. These rules, which are of the very essence of the phenomenon, are strictly obeyed by Algol. But by the Cepheus variable, although likewise composed of a luminous and a non-luminous body, they are disregarded. Its mimina, if eclipses were in any way involved in their production, should virtually coincide with the star's periastron-passage—the periastron in this orbit being 88° from the ascending node, or nearly in our line of sight. In point of fact, they precede periastron by one entire day. Hence, spectroscopic motion, instead of becoming extinct when the lowest phase is attained, proceeds throughout its duration at a relatively high rate, and in an unchanged direction. The star is in course of retreat from the earth no less after than before its minima, which hence demonstrably occur at a part of the orbit where eclipses are impossible. It should be added that the results so far secured at Pulkowa are considered by their author as merely provisional, so that no final judgment can be pronounced on any point connected with them. Still, it is scarcely to be expected that the glaring discrepancy just adverted to will be abolished by any amount of future research.

The system of δ Cephei is transported towards the sun at the rate of 8·7 miles a second. Its visible member gives a spectrum of the solar type, but with some faint solar lines widened and strengthened. All previously known spectroscopic binaries, including the whole class of Algol-variables (so far as their light has been examined), are "white stars," and the rule was held to have some significance as regards their history and development; hence, the discovery of an exception to it deserves note. Delta Cephei is of a full yellow colour, and has an azure companion at 41″, the pair making a tinted combination hardly inferior in beauty to β Cygni. It is unlikely to be of a merely optical nature. Contrasted hues afford in themselves a presumption of physical relationship ; and a common proper motion, according to Mr. Burnham, assures the reality of the tie. But its amount—less than 2″ a century—is, perhaps, too minute to justify his inference.

There is no longer any reason to doubt that all "short-period variables" are really close binaries. Their spectrographic study hence acquires exceptional importance, and cannot fail to be eagerly pursued. Among the stars most promising for investigation are η Aquilæ, ζ Geminorum, and R Muscæ. The last-named object is circumpolar at the Cape ; and although it very slightly exceeds the limit of naked-eye perception at maximum, its inferiority in brightness may well be compensated by the wonderful rapidity of its changes. They are finished in 21h. 20m.,

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the rise from 6·6 to 7·4 magnitude occupying nine, the corresponding descent twelve hours and twenty minutes. Spectroscopic motion may, then, here prove extremely rapid. Nevertheless, since it represents only the projection upon the visual plane of the orbital velocity, the verdict of experience as to its quantity in any particular case cannot be anticipated, unless by a bare surmise. Stars, indeed, presumably exist which, although judged by analogy to be swiftly circulating binaries, will show no trace of line-displacements, simply because their plane of revolution is approximately perpendicular to the line of sight. Such examples would be particularly instructive, as illustrative of light-variation where eclipses could not, by any contrivance of the imagination, be brought into play.

Spectroscopic binaries fall into the three divisions; of eclipse-stars, of which eleven are now known; variables without an eclipse, such as β Lyræ and δ Cephei; and stars of sensibly constant brightness, exemplified by α Virginis and β Aurigæ. Not improbably, however, the last description may prove, on closer inquiry, to be subject to inconspicuous fluctuations, similar to those by which Algol is apparently affected when uneclipsed. Fig. 2 shows the remarkable curves drawn by M. Plassmann (*Beobachtungen Veränd. Sterne*, IV., 1895) to represent his observations of this star during the years 1891–4, which have been to a great extent confirmed by those of M. Anton Pannekoek at Leyden. It will be noticed that the changes indicated are themselves changeable. Another Algol-variable, U Coronæ, was perceived by Schönfeld to waver in brightness, apart from its regularly recurring phases; but little or no attention has, for the last score of years, been paid to the details of its light-curve. In these stars, accordingly, we have an eclipse with complications; in others, we find complications without an eclipse.

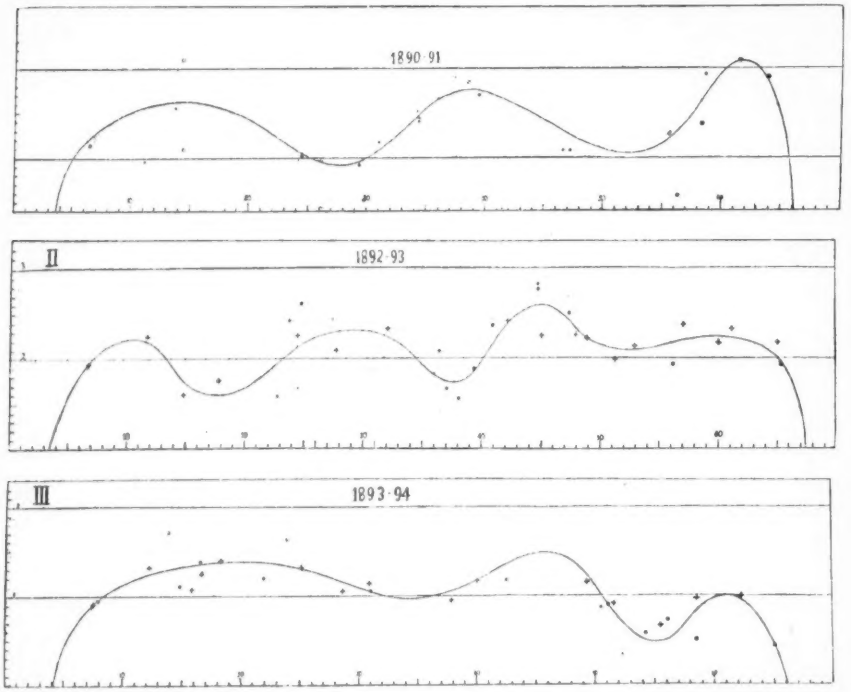


Fig. 2.—Algol in full light. In Curves II. and III. the crosses represent the annual means of Pannekoek's observations; the dots in I., II., and III. standing for Plassmann's corresponding results.

Letter.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

THE WINDS OF MARS.

To the Editor of Knowledge.

Sir,—M. Camille Flammarion, writing on "The Circulation of Water in the Atmosphere of Mars," states there is on that planet "nothing analogous to our trade winds or to the *régime* of predominant winds which govern our terrestrial climate." This is an error. The rapid inundations over immense tracts of land must be caused by considerable heat rapidly melting the snow in the summer; the polar zone then becoming warmer, the prevailing winds would be towards the pole, taking back the water in the shape of vapour to be again deposited in the state of snow, in the winter, at the poles; otherwise, how does he account for the annual accumulation of snow at the poles?

Yours truly,

A. E. Whitehouse.

30, St. George's Place,
London, S.W.,
April 8th, 1895.

[M. Flammarion certainly did not intend it to be understood that there were absolutely no winds or air-currents on Mars. To such an idea Mr. Whitehouse's objection, that there could in that case be no accumulation of snow round the poles, would be fatal. But the feebleness of the action of gravity at the surface of Mars will necessarily cause all air-currents to be much more languid than on the earth. The Martian trade winds will not be trade winds as we know them here, but will be merely steady but very gentle breezes. On the other hand, the vertical currents will be even more restrained, and it will be easier for moisture-laden currents from the equator to travel as upper currents into the polar regions than it is here on the earth, in spite of their moving so much more slowly.

E. Walter Maunder.]

An egg of the great auk, or gare fowl (*Alca impennis*), was sold by auction on the 23rd of April, at Mr. Stevens' rooms in King Street, Covent Garden. The bidding was not very brisk, the price realized being only 180 guineas.

A good stuffed specimen of the great auk was also put up; 350 guineas was the highest bid, but the bird remained unsold. This specimen belongs to Sir F. Milner, and was sold to him by Graham, of York, who stated that it was taken in the Orkneys. Prof. Newton believes that it was originally given by Gardner to the Rev. R. Buddicorn, of Smethcote, Shrewsbury, and purchased from him by Graham; also that it comes from the Rock of Eldey, off the coast of Iceland.

THE WINTER LIFE OF INSECTS—II.

By E. A. BUTLER, B.A., B.Sc.

IN our last paper we considered the manner in which the Coleoptera, or beetles, spend the winter. Turning now to the Hymenoptera, we find insects whose economy is of a totally different type. In one section of this order, that which includes the bees, wasps and ants, we come across the social organization; with this comes in care for the young, associated with a large amount of division of labour, effected by the existence of workers in addition to males and females. This special economy is accompanied by peculiar arrangements for the continuation of the species through the winter. Amongst British bees, the only species that are social in habits are the hive-bee and the humble bees. The former we may neglect, as provision is made by man for its maintenance and well-being; but the latter, as they have to depend upon their own exertions alone, will yield us good illustrations of nature's methods. The economy of the humble bees is somewhat like that of the social wasps, and differs considerably from that of ants. In both humble bees and wasps, it is the females, or queens, large, stout-bodied insects, that survive the winter, the males and workers perishing. They are impregnated in autumn, but do not produce eggs till the following spring. During winter they retire to some sort of shelter and become torpid. Mr. F. Smith speaks of finding humble bees, not in their old nests, but "in the accumulation of rubbish under clumps of furze, in the dry rotten wood of decaying trees, under moss in woods, and repeatedly under stacks of turf on commons." These were all found singly, not in clusters together.

With wasps the case is rather different, as an experience of Mr. T. R. Billups will show. He was entomologizing in January, some years ago, on Wimbledon Common, when he saw three queen wasps flying lazily about the remains of a felled oak. On ripping off the bark in one place, he found no less than thirty-eight more, all in a state of torpidity, and huddled together as close as they could be packed. But though torpid, they were not far gone in their lethargy; the warmth of the hand was sufficient to restore them to activity. The wasps in this instance were *Vespa germanica*, and they were accompanied in their winter retreat by many beetles of various kinds. Great numbers of the same kind of wasp were once found hybernating in a room used for storing furniture. The goods were covered with blankets, and many of the wasps were clinging to these; others had dug their mandibles into the rough woodwork of the room, thus supporting themselves by their jaws, as if conscious that their limbs would become too benumbed during the cold weather to be entirely trusted to.

Upon such hybernating females as these depends entirely the establishment of new colonies the next year, the population of each nest being the offspring of the queen who founded it. Hence it follows that, with the exception of the hybernating females, the wasps and humble bees of any given year are not the same individuals as those of the year before, and the nests of one year are not those of the preceding. In this fact we find the explanation of the great variation in the numbers of wasps that marks different seasons. One year they will swarm to such an extent as to become an intolerable nuisance, while, perhaps, the next year very few will be seen anywhere about. The numbers must largely depend upon how many impregnated females manage to survive the vicissitudes of winter, since the death of each single female will mean the prevention of the birth of a whole nestful, which may reach a total of some hundreds. And, as prevention is better than cure, it should be remembered that prowling wasps seen in early spring are these very queens, which are even then beginning to bestir themselves about the foundation of their annual brood; hence the destruction of one of these is equivalent to cutting off a whole army in the summer-time.

With ants the case is different. Here the workers hybernate as well as the females, and therefore the nests are more correctly to be described as perennial than annual. The males appear, usually, to die in the autumn, shortly after pairing; but this is not universally the case, for Sir John Lubbock records having kept some males of the red ant (*Myrmica ruginodis*) from the month of August, when they were hatched, till the following spring, one of them even living on till the middle of May. However, the usual occupants of the nest in winter would be workers and females, and hence the ants of these sorts met with in one season are in many cases the same individuals as those that were to be seen the year before, though the males would probably, as a rule, be different ones. Of course, in addition to these, new members belonging to all the divisions are hatched each year. It need hardly be mentioned that ants, unlike bees and wasps, hybernate in their own nests.

Turning now to the order Lepidoptera, or butterflies and moths, we find a still greater variety of habit. If there is one creature that, more than another is mentally associated with sunshine and summer skies, it is the "gilded butterfly," and yet, warrantable as such association for the most part is, this is the very order in which, if we take it all round, we find the most numerous examples of activity during the winter. It is true that a very large proportion of the species belonging to this group are quiescent in the winter in one or other of their stages, but yet, as if on purpose to supply the proverbial exception to the rule, there are some that actually choose the winter months as the time of their emergence as perfect insects, and indeed as their sole time of existence in that form. Thus we have the November moth (*Oporabia dilutata*), a thin-winged, slight-bodied, grey insect, the colour of whose wings is a good match to the cloudy skies that characterize the month of its introduction to the world as a flying creature; the winter moth (*Cheimatobia brumata*), a warmer coloured, though equally fragile little moth, whose brown fore-wings, like the grey ones of its predecessor, are crossed by a number of delicate wavy lines; the early moth (*Hybernia rupicapraria*), a larger, though equally fragile insect, which derives its name from its habit of appearing during the first two months of the year; the spring usher (*Hybernia leucophearia*), a very pretty insect which appears a little later, but is still only a harbinger of spring; and several others of the same type. It is a noteworthy fact that the majority of these winter moths have, so to speak, effected an economy in wing material, in that their females are either quite destitute of wings (Fig. 1), or have them reduced to such ridiculously small dimensions as to be quite useless for flight. The males, on the other hand, have ample, though very weak, wings. The females thus run little risk of becoming the sport of tempestuous winter winds, and are enabled to cling to the twigs of the food-plant and perform their maternal duties independently of weather.

FIG. 1.—Wingless Female of Mottled Umber (*Hybernia defoliaria*); natural size.

The above insects all belong to the section called geometric moths or loopers, in allusion to the curious arched position taken by the caterpillars in walking, a

position necessitated by the reduction of the number of their claspers from five pairs to two. Turning to another section, the hairy and thick-bodied moths called Bombyces, we find two species, externally very like their congeners, but differing in emerging during the winter months. These are called the small egger (*Eriogaster lanestris*), and the December moth (*Pœcilocampa populi*). The former appears in February, and the latter in November and December, the normal time being these months in the winter following the summer of their larval existence. But the date of their exit from the cocoon is extremely uncertain, and their appearance is often delayed for two or three years. It is a well-known fact that an increased temperature may result in the more speedy development of a lepidopterous insect when it is in the pupa state, and advantage is taken of this fact by collectors who "force" species to emerge at unusual times. Hence one might readily conclude that a lowering of temperature would have a retarding effect, and that, therefore, such retardations as just mentioned might take place in consequence of an exceptionally severe winter. But that conditions of weather are not wholly responsible for such freaks is evidenced in two ways: first, that the warmth of summer, which, however unfavourable the weather may be, will be certainly higher than that of exceptionally severe winters, does not cause an emergence, but if the insect does not come out during the first winter, it waits till the next comes round; and second, that different members of the same batch, which all pupated at the same time, and have all been exposed to the same conditions of temperature, emerge at very different times, some during the first winter, others during the next, and so on.

Amongst the Noctuæ, or ordinary thick-bodied moths, there are many species, notably those of the genus *Tæniocampa*, that complete their pupal development just at the end of winter, and so appear as perfect insects at the commencement of spring, when they become noted visitors at the catkins of the sallows, which are just then in season. These, though hardly to be classed as winter moths, serve as the connecting link between the truly winter species and the long series of forms that emerge in unbroken succession during the latter part of spring and the whole of summer; and, further, they serve to emphasize the variety that exists in this order in the time of occurrence of the chief changes in the life of the insect. Amongst the smaller moths there is a pretty little greyish species called *Diurnea fagella*, which must also be ranked amongst those that assume the perfect form in winter. It is a narrow-winged insect, which, when resting on tree-trunks looks much like a little scrap of lichen, and it is one of the earliest heralds of the new year, enlivening the yet leafless woods with its short and rather weak flights.

But a warm day in winter may be enlivened by the appearance of other lepidopterous insects than those that actually acquire the winged form at that season, and never live to see the brightness of summer suns. Several species hybernate as perfect insects, and a particularly warm day may entice these from their retreats. Amongst our butterflies there are two species that must specially be mentioned in this connection, the small tortoiseshell (*Vanessa urticæ*) (Fig. 2) and the brimstone (*Gonepteryx rhamni*). The former, one of the most richly-coloured of our British butterflies, belongs to a section which is remarkable for the dissimilarity in colouring that exists between the upper and under sides of the wings. The reddish ground colour of the upper surface passes through various shades from almost scarlet, through deep orange to yellowish. This reddish-orange background is strikingly relieved by angular patches and spots of the deepest black, one of which is bordered by a white patch at the tip of the fore-wing. A broad black band at the hind margin is inlaid with a series of exquisite blue crescents, and then beyond these there is a chaste border of delicately mottled brown running out into a blunt point or tail on each wing. Now, if we turn the creature over on its back, we discover that the under surface exhibits the same general pattern, but in much duller tints, dirty blackish-brown and pale ochreous being the prevailing ones. Like its brethren, this butterfly rests with its wings closed over its back, and thus the glowing brilliance of the upper surface is entirely hidden, and nothing but the dulness of the under surface appears, and this is so inconspicuous that it is quite possible to look at the spot where the insect is resting, perched on some twig, without becoming aware of its presence. Hence the dulness of the under surface must be a valuable means of protection to it, often enabling it, no doubt, to escape the passing notice of hungry birds. Thus there is no difficulty in understanding how, from the similarity of their under colouration to that of dead leaves and dry twigs or tree trunks, they can remain completely concealed throughout the winter, and come out again in spring-time, to complete their cycle of existence. It follows, therefore, that all the tortoiseshell butterflies one sees in spring or early summer are the same individuals that were to be met with during the autumn of the preceding year, and their antiquity is evidenced by the dingy and worn condition of their wings, so different from the brilliance and perfect symmetry of a newly-fledged individual. They often hybernate in houses or public buildings, and a sudden accession of artificial warmth indoors, equally with a natural rise of temperature out of doors, may at any time call them out into premature activity.

Fig. 2.—Small Tortoiseshell Butterfly (*Vanessa urticæ*).

Fig. 3.—Brimstone Butterfly (*Gonepteryx rhamni*).

With the brimstone butterfly the case is somewhat different. This insect (Fig. 3) is almost entirely of a bright sulphur colour above, and the under surface is almost the same, the only difference being that it is a little paler. It rests with wings closed as usual, but this, of course, does not make much difference to its colour. The pale greenish-yellow of the under side serves admirably to conceal the insect amongst the *green* foliage of summer-time, but it seems at first sight difficult to understand how it can be otherwise than most conspicuous in winter, when there is such an absence of light-green leaves. But, according to Rössler and De Selys-Longchamps, they hybernate amongst *fallen* leaves; and as, in sheltered places, these often retain their colour for some time, the colour difficulty is, perhaps, less than might have been imagined. They have also been found in cracks in the ground, sometimes at a considerable depth. Both sexes of these two butterflies live through the winter. The eggs are laid in April and May, and, according to Dr. Chapman, fertilization takes place, at least sometimes, only shortly before their deposition. Thus we see that these two butterflies—and the case

Fig. 4.—Herald Moth (*Gonoptera libatrix*).

of several moths is parallel—conduct their operations upon a different plan from that followed by bees and wasps, in which fertilization takes place during the autumn, and only the females survive the winter, to lay their eggs in the spring. Amongst moths, two of the best-known instances of hybernation in the perfect state are those of the humming-bird moth (*Macroglossa stellatarum*) and the herald moth (*Gonoptera libatrix*) (Fig. 4), both of which may be met with in houses or barns, and the latter sometimes under tunnels and bridges, or in caves.

Some Lepidoptera pass the winter in the egg state, and one of the most remarkable is the lackey moth (*Bombyx neustria*). This insect, though a close ally of the small egger, has a very different life-history. The female lays her eggs while the leaves are still on the trees, but does not attach them to the leaves as most moths would do, but glues them firmly round a twig in the form of a complete bracelet (Fig. 5). If attached to the leaves, they would run great risk of being ruined when the leaves fall, but by being firmly cemented to the twigs, they are able to resist all the storms and rains of winter, and produce their brood when the next crop of leaves is ready for them. Many species hybernate as larvæ, some of them when quite young and small, and others when nearly full-grown. Some construct a roof of silk for their protection in company, while others retire into crevices, or under leaves or stones, and there rest solitary. A very large number of species rest through the winter in that condition which is evidently specially related to the occurrence in nature of an interval during which there is an absence of vegetable food, viz., the chrysalis state, the break in animal activity thus coinciding with that in vegetable growth.

FIG. 5.—Egg Bracelet of Lackey Moth (*B. neustria*) round a Hawthorn Twig; magnified two diameters.

So little is known of the life-history of the great host of two-winged flies, or Diptera, that inhabit these islands, that it is scarcely possible to do more than speculate as to the way in which most of them pass the winter. Some certainly hybernate as perfect insects, and an extra warm day will call them forth from their hiding-places, but their vivacity is far inferior to what it is in summer-time. This, at least, applies to the heavier-bodied flies. But there are some species of gnat-like flies whose special time of appearance is mid-winter. Such is *Trichocera hiemalis*, the so-called winter-midge, the dancing swarms of which may often be seen enjoying themselves in the air when the temperature is sufficiently high. According to the Rev. A. E. Eaton, a temperature of a few degrees above freezing point drives them to their retreats under boards, etc., but it need not rise to more than seven or eight degrees Centigrade for them to congregate in swarms and perform their aërial gyrations.

Amongst the Hemiptera it is certain that very many hybernate in the perfect form, and hence those specimens that are to be found in the early months of one season are the same as those that first appeared as perfect insects in the preceding autumn. Hence, during each year, two perfectly distinct sets of individuals put in an appearance. Even those that are aquatic, to some extent, adopt similar habits. The water-skaters (*Gerris*) (Fig. 6) will even leave the water and in some way, either by jerking themselves along on their stilt-like legs, or by flight, escape to a considerable distance from their native pond, and go into winter quarters amongst low herbage, moss, etc. The skaters that one sees in spring and early summer, therefore, are last year's insects, and their descendants of the next generation begin to appear while their parents are still alive, so that both generations may be met with simultaneously, and on the same pond. As so very little is known of the life-history of this order of insects, it is scarcely possible to say anything more definite about them. How, when, and where they lay their eggs—these are questions to which, in most cases, no definite answer can be given.

FIG. 6. — Water Skater (*Gerris lacustris*).

It is a most unusual thing for such an insect as a dragon-fly to pass the winter in the perfect condition. According to Mr. McLachlan, only one species is known to hybernate, and that is not a British one. It belongs to the thin-bodied section, and is found in France. It remains concealed amongst heather during the cold weather, coming out and flying about whenever the sun is bright enough. Of the Orthoptera, space will not permit us to say more than that the common earwig may be found at any time during the winter, in hiding, but always ready to start into activity, and that a small kind of grasshopper was on one occasion found hybernating contrary to custom.

Finally, we may note that to hybernating insects, in whatever condition they may be, the greatest enemy does not seem to be cold. After a severe winter, insects are often much more plentiful than after a mild one, and the explanation seems to be that while they can stand a considerable reduction of temperature without damage, the milder weather, which is usually also damp, encourages the growth of mould, one of the greatest enemies of quiescent insects, and keeps insectivorous creatures more active than they would otherwise be.

Notices of Books.

Popular Astronomy. By Camille Flammarion. Translated from the French by J. Ellard Gore, F.R.A.S., &c. Pp. 679. (Chatto & Windus.) When a work has reached a sale of more than one hundred thousand copies, it is late in the day to discuss its merits. Flammarion's "Astronomie populaire" attained that distinguished place among scientific works some time ago, and its excellence obtained for the author the Montyon prize of the Paris Academy, as well as other honours. Few translations, however, are very successful, not so much because of the translators' imperfect renderings of the originals, but because the eloquent expressions which make an attractive pabulum for readers of one nationality do not appeal to a public used to another and a foreign idiom. M. Flammarion's power to write in very popular language is undoubted; he is gifted with a vivid imagination, which he uses with due regard to facts. But when we come to read this translation of his most successful work, we confess that much of the writing which appears so sublime to French readers approaches the ridiculous when dressed in our sober English garb. It is too flowery, too florid altogether, to be read with pleasure. However, the fault does not lie with Mr. Gore, who has translated the work into as readable English as the original idioms permitted. Here and there he adds notes of his own, and in a few cases these are, perhaps, a little too numerous. The following interpolations, for instance, on page 79, makes the text look very strange:—"We have already seen

twenty-five stars blazing out in the sky with a spasmodic gleam, and relapsing to an extinction bordering on death [the number of *well-authenticated* cases of 'temporary stars' is much less than twenty-five.—J. E. G.]; already bright stars observed by our fathers have disappeared from the maps of the sky [that any *bright* stars have really disappeared is very doubtful.—J. E. G.]; a great number of red stars have entered on their period of extinction [that red stars are really cooling down is now a disputed question.—J. E. G.]" Putting aside these minor blemishes, we regard Mr. Gore's translation as a decided acquisition to our astronomical literature. No popular book on general astronomy in the English language is better illustrated, and none offer easier or more interesting reading.

A Student's Text-book of Botany. By Prof. S. H. Vines, M.A., D.Sc., F.R.S. Pp. 821. (Swan Sonnenschein & Co.) Students of botany have for some time been looking forward to the completion of this valuable text-book, which, though based upon Prof. Prantl's "Lehrbuch der Botanik," is much more extensive in its scope and treatment. The work is hardly suitable for beginners, but advanced students of botany, who are not afraid of new terms, and who want to know the chief important results of modern botanical researches, will find that Prof. Vines has admirably supplied their need. The morphology of plants forms the subject of the first part of the work, and this leads to Part II., in which the intimate structure of plants (Anatomy and Histology) is studied. In the third part, the classification of plants is dealt with, the four groups, Thallophyta, Bryophyta, Pteridophyta and Phanerogamia, with their different classes, being taken in order. Finally, the physiology of plants is treated in Part IV. There are nearly five hundred illustrations in the book, but few of them are new. Notwithstanding this, the volume, taken as a whole, will certainly rank high among the best and most comprehensive English manuals of botany.

Mechanics: an Elementary Text-Book, Theoretical and Practical, for Colleges and Schools. By R. T. Glazebrook, M.A., F.R.S. (Cambridge: University Press.) This text-book, belonging to the physical series of Cambridge Science Manuals, is published in two separate parts, dealing respectively with dynamics and statics. It differs from most books on mechanics in the fact that a larger share of attention is given to descriptions of experiments to be performed by the students themselves. Only by such practical work can a scientific knowledge of the fundamental principles of the subject be obtained. Most of the apparatus for the experiments is simple, and much of it can be easily constructed by the pupils. Whenever possible, theoretical consequences are deduced from the results of the experiments. These are the right lines to work upon, and the more books in which this scientific method is followed, the greater will be the advancement of natural knowledge. We cordially commend Mr. Glazebrook's volumes to the notice of teachers.

An Elementary Text-Book of Hydrostatics. By W. Briggs, M.A., F.C.S., and G. H. Bryan, M.A. Pp. 204. (University Correspondence College Press.) Students working up for the matriculation examination of the London University, could not have a more suitable text-book for the portions of hydrostatics and pneumatics included in it than is given in this volume. The descriptions are concise, the illustrations are instructive, and the examples are numerous and well-chosen. At the same time the book is not a mere means for "cramming," but a good and accurate volume in which results are scientifically deduced from first principles.

The Story of the Stars. By G. F. Chambers, F.R.A.S. Pp. 186. (George Newnes, Ltd.) Mr. Chambers has contrived to compress a mass of information on all branches of sidereal astronomy into a very small compass. He tells his story simply, and in a manner that should be acceptable to general readers, while amateur astronomers will find the book a handy and valuable record of what is known in many departments of celestial science.

Remarkable Comets. By W. Thynne Lynn. Third edition, pp. 42. (Edward Stanford.) We are glad to see the third edition of Mr. Lynn's little *brochure* on interesting comets. For the modest sum of sixpence, this slender treatise provides a trustworthy account of all comets of note in astronomical history. To know the contents of the book is to have a liberal education in cometary matters.

BOOKS RECEIVED.

Practical Microscopy. By George E. Davis, F.R.M.S., F.I.C. Third Edition. Illustrated. (W. H. Allen & Co.) 7s. 6d.

Annual Report of the Smithsonian Institution for the year ending June 30th, 1893. (Government Printing Office, Washington.) Illustrated.

Chemical Analysis of Oils, Fats, Waxes. From the German of Prof. Dr. R. Benedikt; revised and enlarged by Dr. T. Lewkowitsch. (Macmillan.) 21s. net. Illustrated.

Molluscs and Brachiopods (Recent and Fossil). By Rev. A. H. Cooke, M.A., A. E. Shipley, M.A., and F. R. C. Reed, M.A. (Macmillan.) 17s. net. Illustrated.

A Handbook of Systematic Botany. By Dr. E. Warming. (Fungi by Dr. E. Knoblanch.) Translated by M. C. Potter, M.A. (Swan Sonnenschein & Co.) 15s. Illustrated.

Allen's Naturalist's Library: A Handbook to the Carnivora. Part I. By Richard Lydekker, B.A., F.R.S. (W. H. Allen & Co.) 6s. Illustrated.

Short Studies in Nature Knowledge. By William Gee. (Macmillan.) 3s. 6d. Illustrated.

Wayside and Woodland Blossoms. By Edward Step. Illustrated. 7s. 6d. (Warne & Co.)

Rain, River and Evaporation Observations made in New South Wales during 1893. By H. C. Russell, B.A., &c. (Sydney: Charles Potter.) 3s 6d.

Meteorological, Magnetical and Solar Observations during 1894. By Rev. W. Sidgreaves.

We understand that the Rev. W. Sidgreaves has several surplus copies of this book, and he has kindly said that they are at the disposal of the subscribers to KNOWLEDGE. Readers who are desirous of accepting this kind offer should communicate to the KNOWLEDGE Office.

Transactions of the Astronomical Society of Toronto for 1894. (Toronto: Rowsell & Hutchison.) 1 dollar.

Proceedings of Society for Psychical Research: March. (Kegan Paul.) 2s. 6d.

Bradshaw's Dictionary of Health Resorts. (Kegan Paul.) 3s. 6d.

The Royal Natural History. Edited by Richard Lydekker, F.R.S. (Warne.) 1s. Vol. III., Part 18.

THE BALTIC STREAM.

By RICHARD BEYNON.

HYDROGRAPHICAL research presents few more interesting problems than those connected with the Baltic Sea and its approaches. Until quite recently this vast land-locked sea was one of mystery to the student of oceanic lore. Even now the British shipmaster is advised that he must not place implicit reliance upon the soundings and current data which are laid down for his assistance when

navigating this dangerous seaway, and its no less perilous offsets.

Roughly speaking, the Baltic Sea may be regarded as a series of submarine plateaux, hollows and channels, separated by shallow ridges. In some of these deeper depressions or pools there is little, if any, circulation of the water. Over the shallow ridges, however, there is abundance of movement, and that, too, of a most complex character; for over these the incoming waters from the North Sea and the outflowing waters from the Baltic must flow.

The rivers which pour their tributary waters into this sea are numerous. There is in addition a copious rainfall upon its surface, and, as may be imagined from the general climatic conditions which obtain over the Baltic area, the evaporation is by no means great. There is thus an excess of supply over evaporation. The surplus resultant finds its way into the North Sea through the channels already alluded to, and by the same means of communication must enter the warmer and salter currents from the adjoining German Ocean. It is this mingling of the waters which is accountable for the ground, anchor, or pancake ice of the Baltic and its connections.

The Baltic stream, as the outflowing waters are styled, is thus a creep of colder and fresher water than that which obtains in the adjacent ocean. In winter the rivers are icebound and the flow of the stream diminishes. In February or March, when the advent of warmer weather releases the waters of the icebound streams, the flow assumes again its normal proportions.

This superposition of layers of water of different densities and different temperature plays, during the winter months, an important part in the production of what is, in some cases at least, erroneously termed ground ice. The phenomenon of ground ice is no recent discovery. Long ago it was matter of pretty common observation that, under certain circumstances, ice was formed at the *bottom* of sheets of water, more especially of rivers. The explanation as to the formation of this variety of ground ice is a simple one. It is well known that running water does not freeze so readily as that which is still, so that it is quite possible, by reason of the constant movement among the particles of water in a rapidly flowing stream, that the temperature of this water may be reduced considerably below the freezing point before ice is formed. It is easy to imagine water in this condition transferred, by the mechanical action of an onmoving stream, from surface to river bed. Here, at the bottom, ice is formed owing to the greater stillness of the water, and the fact that rocks, stones, and shingle offer so many points upon which the water can freeze. An increase in the bulk of this ice, or the raising of the temperature, and the consequent reducing of the density of the water flowing over it ensures that the buoyancy of the ice asserts itself, and the subaqueous formed ice floats upon the surface. Such ice always carries with it the marks of its ground origin in the shape of the stones, gravel, mud or weeds which are frozen into its under surface.

The so-called ground ice of the Baltic is not of this type. It is more analogous to that which came under the observation of Captain Scoresby and other early Arctic navigators. They reported ice as observed in the very act of rising to the surface from the depths of the sea, at considerable distances from the Greenland coast. Cakes of this ice, when carefully examined, show no sign of earthy contact on their under side. It is really sea ice crystallized not on the surface of the sea, but in it.

The suggestion that sea ice in the Polar regions or the Baltic Sea should be formed anywhere but at the surface was at one time looked upon with open disbelief. The main difficulty in the way of accepting what at first seems so contradictory a phenomenon lies in the fact that with fresh water the point of greatest density is reached some seven degrees sooner than the freezing point. Thus, in ponds and lakes where the conditions are normal, the coldest water after 39° Fahr., the temperature of the point of maximum density, has been passed will be the lightest, and hence surface-freezing; but these conditions are not applicable to the crystallization of fresh or salt water under all circumstances.

Perhaps the Baltic Sea and its offsets furnish the best and most interesting example of the so-called ground ice of the sea, upon a big scale. The freezing point of the water composing the Baltic stream is, of course, higher than that of the salter water which flows into the Baltic, mainly as an under-current from the North Sea. The temperature of this underlying stratum may be below the freezing point of the fresher water which is superincumbent to it. When this is so it is easy to suppose the fresher water, chilled by contact with a keen and nipping air to its point of maximum density, sinking slowly downwards to the colder and salter stratum beneath. Here the temperature is such that it is speedily reduced to the freezing point, and cakes of ice are actually formed at the point of contact of the two layers of water. Of course, the formation of ice in this manner in the intermediate layers of the sea is influenced also by the eddies which the mixing of such currents as these must produce.

The winter of 1892-3 will long be remembered on account of the damage inflicted by ice upon shipping in the Baltic and its approaches. Large and staunch vessels were prevented from proceeding by the rapidly formed and erroneously named ground ice. The cakes of ice no sooner reached the surface than the process of regelation cemented the fragmentary ice into a compact field. Fishermen, plying their necessary calling at no great distance from the shore, saw the clear belt of water become quickly covered with an ever-growing expanse of ice which cut off all chance of navigating their vessels to land. In many cases the pack in which the fishers' boats, the sailing craft, or the smaller steamers became involved, drifted out to sea, where the vessels were crushed, their occupants perishing miserably.

Some Recent Patents.

J. G. Stidder, Croydon. An improved method of forming the joints of pipes for steam, water, and other fluids. Figs. 1 and 2 show the invention, in elevation and section. *a* is one end of a socket into which the pipe *b* is screwed. *c* is an annular recess formed in the socket, in which a ring of asbestos, copper, lead, rubber, cord, or other suitable material *d* is inserted, with or without the addition of red lead and the like, as required. *e* is a screw collar or back nut, also formed with an annular recess and a projection *f* which enters the recess in *a*, a short distance. The back nut is screwed up until the joint is perfectly fluid tight.

Four figures. Dated 25th April, 1894. *Accepted 2nd March*, 1895. *No.* 8023.

Fig 1

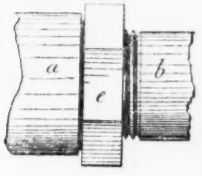
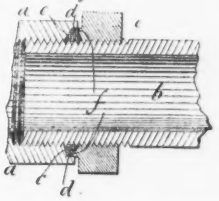
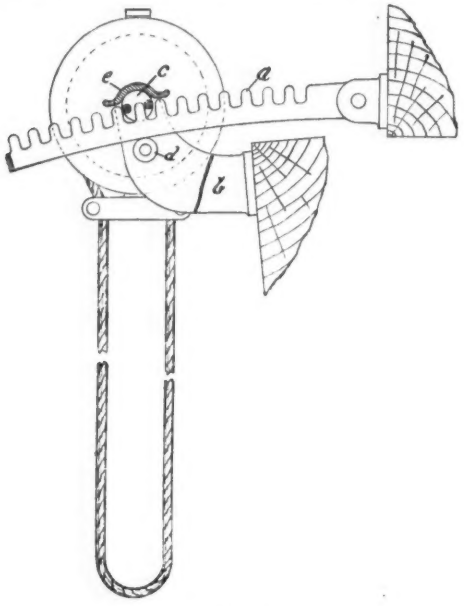


Fig 2



W. Connell, Glasgow. Improvements in apparatus for regulating fanlights and skylights. The drawing renders the invention very clear. *a* is a toothed rack, with deep teeth, pivoted to the frame of the window. *b* is a bracket fixed to the window, one of the cheeks of the bracket being shown broken off, to expose to view the pinion *c*, having two teeth only. The pinion may be revolved by a pulley and cord as shown, and thus made to travel along the rack, carrying the window with it. *d* is a small guide pulley, and *e* is a guard, both attached to the bracket *b*.

Dated 28th April, 1894. *Accepted 2nd March*, 1895. *No.* 8453.



S. F. Pichler, London. Improvements in or relating to plating or covering articles with metal. The inventor says: "I take liquid collodion or analogous compound, and, after thinning the same (if necessary) with alcohol and ether, I mix therewith powdered aluminium, aluminium bronze, silver, gold, or other powdered metal." He then proceeds to show the methods of applying the metals to the purposes of tipping cigars, cigarettes, and the like, to prevent the lips coming in contact with the leaf or paper, the covering being perfectly tasteless; forming a hard yet cellular mouthpiece, and preventing the tobacco becoming loose and entering the mouth. Also photographic reproductions affixed to glass may be covered with the mixture, instead of white paper, imparting thereto a brilliant appearance. Also for capsuling bottles, and many other obvious applications, the plating being air and water proof, and also proof against sulphuric and nitric acids.

Dated 10th May, 1894. *Accepted 16th March*, 1895. *No.* 9261.

THE FACE OF THE SKY FOR MAY.

By Herbert Sadler, F.R.A.S.

SPOTS and faculæ are still visible in considerable numbers on the solar disc. Algol is too low on the northern sky for minima to be conveniently observed.

Mercury is in superior conjunction with the Sun on the 5th, and is too near that luminary to be conveniently observed until the middle of the month. On the 14th he sets at 8h. 52m. P.M., or 1h. 12m. after the Sun, with a northern declination of 22° 31′, and an apparent diameter of 5·4″, $\frac{88}{100}$ths of the disc being illuminated. On the 17th he sets at 9h. 14m. P.M., or 1h. 30m. after the Sun, with a northern declination of 23° 52′, and an apparent diameter of 5·6″, $\frac{8}{10}$ths of the disc being illuminated. On the 22nd he sets at 9h. 44m. P.M., or 1h. 52m. after the Sun, with a northern declination of 25° 15′, and an apparent diameter of 6·2″, $\frac{7}{10}$ths of the disc being illuminated. On the 31st he sets at 10h. 8m. P.M., or 2h. 5m. after the Sun, with a northern declination of 25° 25′, and an apparent diameter of 7·4″, $\frac{48}{100}$ths of the disc being illuminated. While visible he describes a direct path through Taurus into Gemini, being north of η and μ Geminorum at the end of the month.

Venus is an evening star, and is the brightest object in the evening sky. On the 1st she sets at 10h. 47m. P.M., with a northern declination of 24° 13′, and an apparent diameter of 13·4″, $\frac{79}{100}$ths of the disc being illuminated. On the 11th she sets at 11h. 7m. P.M., or 3h. 30m. after the Sun, with a northern declination of 25° 25′, and an apparent diameter of 14·2″, $\frac{76}{100}$ths of the disc being illuminated. On the 21st she sets at 11h. 18m. P.M., with a northern declination of 25° 19′, and an apparent diameter of 15·2″, $\frac{72}{100}$ths of the disc being illuminated. On the 31st she sets at 11h. 19m. P.M., with a northern declination of 24° 4′, and an apparent diameter of 16·2″, $\frac{68}{100}$ths of the disc being illuminated. During May, Venus passes from Taurus into Gemini, being near the 3rd magnitude star ε Geminorum on the 19th and 20th.

Mars is, for all practical purposes, invisible.

Jupiter is an evening star, but is so rapidly approaching the west that our ephemeris of him extends to the first three weeks of May only. On the 1st he sets at 11h. 53m. P.M., with a northern declination of 23° 28′, and an apparent equatorial diameter of 33·9″. On the 11th he sets at 11h. 22m. P.M., with a northern declination of 23° 26′, and an apparent equatorial diameter of 33·0″. On the 21st he sets at 10h. 50m. P.M., with a northern declination of 23° 21′, and an apparent equatorial diameter of 32$\frac{3}{4}$″. The following phenomena of the satellites occur while the planet is more than 8° above and the Sun 8° below the horizon. On the 5th a transit egress of the shadow of the third satellite at 10h. 13m. P.M. On the 7th an occultation disappearance of the first satellite at 9h. 6m. P.M. On the 8th a transit egress of the first satellite at 8h. 34m. P.M., and a transit egress of its shadow at 9h. 31m. P.M. On the 10th a transit egress of the second satellite at 8h. 48m. P.M. On the 15th a transit ingress of the shadow of the first satellite at 9h. 8m. P.M. On the 17th a transit ingress of the second satellite at 8h. 54m. P.M. On the 22nd a transit ingress of the fourth satellite at 9h. 18m. P.M. During May, Jupiter describes a direct path in Gemini, to the east of μ Geminorum.

Saturn is an evening star, and is well situated for observation, though his altitude above the horizon is not large. He rises on the 1st at 6h. 20m. P.M., with a southern declination of 10° 5′, and an apparent equatorial diameter of 19″ (the major axis of the ring-system being 43$\frac{1}{2}$″ in diameter, and the minor 12$\frac{3}{4}$″). On the 7th he rises at 5h. 52m. P.M., with a southern declination of 9° 57′, and an apparent equatorial diameter of 19″ (the major axis of the ring-system being 43$\frac{1}{2}$″ in diameter, and the minor 12$\frac{1}{2}$″). On the 14th he rises at 5h. 22m. P.M., with a southern declination of 9° 47′, and an apparent equatorial diameter of 18$\frac{3}{4}$″ (the major axis of the ring-system being 34$\frac{3}{4}$″ in diameter, and the minor 12$\frac{1}{2}$″). On the 21st he rises at 4h. 52m. P.M., with a southern declination of 9° 39′, and an apparent equatorial diameter of 18$\frac{3}{4}$″ (the major axis of the ring-system being 43·0″ in diameter, and the minor 12$\frac{1}{4}$″). On the 31st he rises at 4h. 10m. P.M., with a southern declination of 9° 29′, and an apparent diameter of 18$\frac{1}{2}$″ (the major axis of the ring-system being 42$\frac{1}{2}$″ in diameter, and the minor 12·0″). Titan is at his greatest eastern elongation at 4h. P.M. on the 1st, and 1$\frac{1}{2}$h. P.M. on the 17th; and Iapetus at greatest eastern elongation

on the 13th, and in inferior conjunction on the 31st. During May, Saturn pursues a short retrograde path in Virgo, being less than $\frac{1}{4}°$ north of the 4th magnitude star κ Virginis on the 4th, and within 10′ of the 7th magnitude star 96 Virginis on the 19th.

Uranus is an evening star, but owing to his great southern declination he is not very well placed for observation. On the 1st he rises at 7h. 50m. P.M., with a southern declination of 16° 56′, and an apparent diameter of 3·8″. On the 31st he rises at 5h. 45m. P.M., with a southern declination of 16° 35′. He is in opposition on the 8th, at a distance from the earth of about 1642½ millions of miles. During May Uranus pursues a short retrograde path in Libra, without approaching any naked-eye star.

Neptune has left us for the season.

There are no very well marked showers of shooting stars in May.

The Moon enters her first quarter at 3h. 44m. A.M. on the 2nd; is full at 11h. 59m. P.M. on the 8th; enters her last quarter at 5h. 44m. P.M. on the 16th; is new at 0h. 46m. P.M. on the 24th; and enters her first quarter at 8h. 48m. A.M. on the 31st. She is in perigee at 10h. A.M. on the 4th (distance from the earth 229,070 miles); in apogee at 8h. P.M. on the 16th (distance from the earth 251,030 miles); and in perigee again on the 29th (distance from the earth 229,320 miles). At 7h. 50m. P.M. on the 4th the 5th magnitude star τ Leonis will disappear at an angle of 120°, and reappear at 9h. 0m. P.M. at an angle of 315°. At 7h. 38m. P.M. on the 6th the 6th magnitude star 49 Virginis will make a near approach at an angle of 216°, and at 8h. 0m. P.M. the 6th magnitude star 50 Virginis will make a near approach at an angle of 37°. At 3h. 42m. A.M. on the 8th the 6th magnitude star B.A.C. 4722 will disappear at an angle of 41°, and reappear at 4h. 4m. A.M. at an angle of 0°, the star being below the horizon of Greenwich. At 9h. 21m. P.M. on the 9th the 6th magnitude star 4 Scorpii will make a near approach at an angle of 204°, and at 10h. 15m. P.M. the 3rd magnitude star π Scorpii will disappear at an angle of 77°, and reappear at 11h. 14m. P.M. at an angle of 328°. At 3h. 11m. A.M. on the 12th the 4th magnitude star γ^1 Sagittarii will disappear at an angle of 148°, and reappear at 3h. 50m. A.M. at an angle of 205°. At 2h. 29m. A.M. on the 17th the 6th magnitude star 45 Aquarii will disappear at an angle of 79°, and reappear at 3h. 40m. A.M. at an angle of 226°. At 10h. 54m. P.M. on the 30th the 6th magnitude star 45 Leonis will disappear at an angle of 183°, and reappear at 11h. 20m. P.M. at an angle of 287°.

Chess Column.

By C. D. Locock, B.A.Oxon.

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 12th of each month.

Solution of April Problem.

(J. T. Blakemore.)

1. B to B5, and mates next move.

Correct Solutions received from N. Alliston, J. M'Robert, A. E. Whitehouse, W. Willby, W. O. Brigstocke, E. W. Brook, F. V. Louis, A. Louis, H. S. Brandreth, G. G. Beazley, Norman Reeve, W. W. Strickland.

Additional solution of March Problem (No. 2) from J. M'Robert (too late to acknowledge last month); also of the December Problems, from W. W. Strickland.

W. W. Strickland.—We do not remember receiving your solution of Signor Orsini's problem. Probably it was lost in the post.

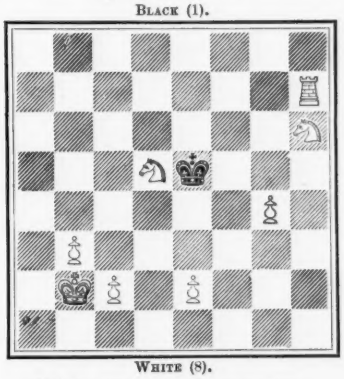
A. C. Challenger.—Thanks; they are marked for insertion next month.

G. E. Barbier.—Many thanks for enclosure.

PROBLEM.

By N. Alliston.

Black (1).



White (8).

White mates in three moves.

The inter-University Chess Match was played, as usual, at the British Chess Club, in the boat-race week. Oxford won by the odd game, their first success for six years. The following was the score :—

Oxford.		Cambridge.	
E. Lawton (C.C.C.)	0	P. Hart-Dyke (King's)	1
P. W. Sergeant (Trinity)	0	H. J. Snowden (Queen's)	1
H. G. W. Cooper (Oriel)	1	W. Naish (Emmanuel)	0
H. K. Robbins (C.C.C.)	1	C. Varley (Christ's)	0
T. B. Collins (Ch.Ch.)	0	D. R. Fotheringham (Queen's)	1
E. G. Spencer Churchill (Magdalen)	1	W. T. Quin (Caius)	0
H. Lake (Lincoln)	1	J. B. Foster (Trinity)	0
	4		3

We give below one of the best-played games in the match :—

"Ruy Lopez."

Spencer Churchill (Oxford). White.	W. T. Quin (Cambridge). Black.
1. P to K4	1. P to K4
2. Kt to KB3	2. Kt to QB3
3. B to Kt5	3. P to QR3
4. B to R4	4. Kt to B3
5. Castles	5. P to Q3 (*a*)
6. P to Q4	6. B to Q2
7. Kt to B3	7. Kt to K2 (*b*)
8. P × P	8. P × P
9. B to Kt3 !	9. Kt to Kt3 (*c*)
10. Kt to KKt5 (*d*)	10. B to K3
11. Kt × B	11. P × Kt
12. B × P	12. P to B3 (*e*)
13. Q × Qch	13. R × Q
14. B to K3	14. B to Kt5
15. P to B3	15. B × Kt
16. P × B	16. R to Q3 (*f*)
17. B to B8	17. P to Kt4
18. B × P	18. K to B2
19. P to B4	19. R to QKtsq
20. QR to Ktsq	20. R to Q2

21. P×P	21. P×P
22. B×P	22. QR to Kt2
23. P to QR4	23. Kt to K2
24. B to R7 (*g*)	24. R×QB
25. B to B4ch	25. K to Kt3
26. R×R	26. R×P
27. B to Q3	27. R to Q5
28. R to Kt6 (*h*)	28. K to B2
29. KR to Ktsq	29. Kt to Q2
30. QR to Kt4	30. R to Q3
31. B to B4ch	31. K to B3
32. B to K2 (*i*)	32. Kt to KKt3
33. R to Ksq	33. K to K2
34. R×R	34. K×R
35. B to B4 (*j*)	35. K to B4
36. R to Kt7	36. Kt to B3
37. B to Q5	37. Kt to R4
38. P to QB4	38. Resigns.

NOTES.

(*a*) 5. . . . Kt×P is more usual, but not necessarily better.

(*b*) This cramps his game. 7. . . . Kt×QP or 7. . . . BK2 may safely be played.

(*c*) Black must lose a Pawn: for if 9. . . . B to Kt5, 10. Q×Qch, and 11. Kt×P.

(*d*) It is astonishing how often this move is overlooked by fairly strong players, unless the opening happens to be the "Two Knights' Defence."

(*e*) This weakens the Queen's side by a "hole," which White promptly proceeds to attack. Probably 12. . . . B to Q3, with a view to Q to K2, and castling one side or the other, is as good as anything.

(*f*) A mistake which loses another Pawn. The Bishop cannot be shut in, as PQR4 is always available to free it. It is difficult, however, to find a satisfactory move for Black, the two Knights being powerless against the two Bishops in such a position.

(*g*) This wins the exchange, and might have been played last move, in which case the BP would have been lost instead of the RP. One is almost tempted to win with the Pawns, keeping the two Bishops, but, of course, the Knight can play to QB3.

(*h*) With a view to P to KB4. On his next move, perhaps, R to Rsq is preferable.

(*i*) Evidently in order to force the exchange of Rooks. Black should prevent this, though nothing, of course, can alter the result.

(*j*) Intending probably 36. R to Kt7, K to B3; 37. B to Q5ch. The whole game was conducted by the Oxonian in a thoroughly scientific manner. It is surprising, indeed, that he occupied so low a position as sixth in the team.

CHESS INTELLIGENCE.

The Hastings International Tournament Fund is progressing satisfactorily, and it is expected that the first prize will be £180. The first Monday in August is the probable date of the tournament, which may last some three weeks.

There have been a large number of small matches recently. Among other results, Mieses beat Taubenhaus at Glasgow by two games to one, with two draws; Von Bardeleben beat Von Gottschall at Leipsig without much difficulty, after losing the first game. The winner should be in good practice for his match with Blackburne, just commencing at the British Chess Club. In America, E. Delmar has defeated Jasnagrodsky by an unexpectedly large majority; Taubenhaus beat Golmayo, the Cuban champion, before sailing for Europe; while G. H. D. Gossip, the well-known writer on the game, added to his laurels a drawn match with W. H. K. Pollock.

The Brighton Chess Club offer four prizes for a problem tournament, limited to three-move direct-mates. Entries, with entrance fee 1s., should be sent to Dr. Hunt, Chess Editor of *Brighton Society*, 101, Queen's Road, Dalston, N.E., on or before September 2nd next.

Dr. S. F. Smith has won the championship tournament of the City of London Chess Club. Mr. Herbert Jacobs was last year's champion.

The adjudication on the unfinished game in the recent match between Surrey and Kent left the result a tie. Sussex accordingly was declared the winner in the south-eastern section, with a score half a point above Surrey. Sussex play Northamptonshire on May 8th, and the winner will then play the final tie against either Gloucestershire or Wiltshire. Surrey won the competition last year without much difficulty, after the preliminary ties in the south-eastern district, where the real struggle for supremacy may at present be said to take place.

The tournament of the New York State Chess Association resulted as follows:—First prize, D. G. Baird; second, J. W. Showalter; third, A. B. Hodges and J. S. Ryan. There were fourteen competitors, seven of whom took part in the recent cable match. Among the others were Messrs. Taubenhaus and Jasnagrodsky.

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NOTICES.

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